

Pan-African Grain Legume & World Cowpea Conference



Sustainable Grain Legume Systems for Food, Income and Nutritional Security in a Rapidly Changing Climate

28 February to 4 March 2016

Livingstone, Zambia

Book of Abstracts



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Paper Number: 1002

Comparing Efficiency of Hermitic and Non-Hermitic Storage Technologies Among Legume Farmers in Nigeria.

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To proffer solution to post harvest losses (PHL) of grains in storage, 2010 grain farmers were randomly selected and interviewed in Nigeria to assess efficacies of different storage technologies they used for grain legumes. Four storage technologies were compared including Traditional granaries (TG) and Woven bag (WB) that are non-hermitic; and AirtightDrum/can(AD), and PICS bag(PICS) that are hermitic in nature. In addition, Logit model was used to model determinants of farmers' storage decision. The result shows that average storage period was highest for PICS both for quantity stored for sale (6.1 months) and for quantity stored for consumption (10.7 months), quantity of grain lost during storage was least with PICS (1.2 kg), followed by AD(12.2 kg). PHL was lowest with PICS (0.1%) followed by AD (2.8%); LSD values show that the results were significant. Highest source of loss to storage grain was insect pest (54.2%), and when disaggregated by 'types of storage technologies' farmers indicated that PICS was least susceptible to insect attack (23.4%). The result further shows that the 'use of protectants (insecticides) was lowest with PICS (9.4%). Using Logit model, factors encouraging probable storage of legume grains included the use of hermitic technology ($p < 0.05$) and the use of protectant ($p < 0.1$) while cash liquidity of grain farmers at harvest time ($p < 0.05$) discouraged their storage among others. Using protectants for storage pose health hazard to man/livestock, the use of hermitic storage especially 'PICS' bag is recommended since this study adjudged it to be the best option in controlling for insect pest.

Paper Number: 1003

Comparative Field Assessment of Alternatives to Synthetic Pesticides in Cowpea Grain Storage.

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Cowpea is widely grown in Southern Africa due to its nutritional value and wide adaptability to different edaphic and climatic conditions. Farmers incur considerable postharvest losses despite using different synthetic and botanical pesticides. Consequently, farmers have increased dosages and/or increased pesticide application frequencies; increasing the risk of food poisoning and pest resistance to pesticides.

To find safe and sustainable cowpea grain storage solutions, nine treatments are being evaluated for efficacy, against *Callosobruchus rhodesianus*, under smallholder management in two contrasting agro-ecological regions. The treatments are hermetic treatments (metal silo, Purdue Improved Crop Storage (PICS) bags and Super Grain bags), ZeroFly bags, Shumba Super dust and Actellic Gold synthetic pesticides, *Colophospermum mopane* fresh leaves, *Eleusine coracana* (finger-millet) chaff and an untreated control. The treatments are arranged in a randomized complete block design with four blocks, replicated four times per site. One kilogram samples are collected from each treatment replicate at 8-week intervals over a period of eight months, and analyzed for insect grain damage levels and pest populations by species. Results at four months show significant differences ($p < 0.01$) in numbers of live and total insect pests, with high populations recorded in untreated control, finger-millet chaff and ZeroFly bags. Significant differences in grain damage levels ($p < 0.001$) were recorded between treatments, with ZeroFly bags sustaining 76.6% from an initial of 1%. Indications are that hermetic treatments are effective in reducing pest build-up and grain damage levels at both sites. The technologies have potential application for both safe cowpea food grain and seed storage in Southern Africa.

Paper Number: 1004

Cross-Country Evidence of Postharvest Loss in Sub-Saharan Africa: Insights from Purdue Improved Crop Storage (PICS).

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Improving staple crop production is widely viewed as crucial for increasing food security and reducing poverty in Sub-Saharan Africa (SSA). However, it is essential to recognize that food security challenges do not simply end at harvest (Affognon et al. 2015). Smallholder farmers in SSA face numerous challenges after their grain leaves the field. Farmers who store grain may experience significant quantity losses due to damage from rodents, insect pest and mold and subsequent price discounts for damaged grain (Kaminski and Christiaensen 2014; Kadjo et al. 2015; Kadjo et al. 2016). Part of the reason quantity loss occurs is that many farmers lack access to effective storage technology, such as airtight (hermetic) storage bags or metal silos. These technologies have the potential to positively impact household welfare but are currently not available in many rural settings (Jones et al. 2011; Gitonga, et al. 2013).

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In addition, households may have their food safety and health jeopardized when they store grain if they apply storage chemicals inappropriately or consume grain that has been infected with mold and aflatoxins (Hoffman and Gatobu 2014). All of these storage challenges undermine household income, food security and nutrition, food safety, and health. The objective of this presentation is to share results on Postharvest Loss (PHL) in legume crops (including cowpea, common bean, etc.) from six countries in sub-Saharan Africa (SSA).

Data was collected from smallholder farmers as part of the Purdue Improved Crop Storage (PICS) project funded by the Bill & Melinda Gates Foundation. Household surveys were conducted in Nigeria (2,010 households), Uganda (1,193 households), Tanzania (309 households), Ethiopia (300 households), Ghana (312 households) and Burkina Faso (300 households). In addition to household characteristics, grain storage practices were assessed including use of storage technology, marketing practices, PHL and sources of PHL. We measure PHL as the percent postharvest loss of the quantity stored by the household.

The goal of this paper is to understand how postharvest losses impact smallholder households marketing of these crops and their food security. These findings will highlight the need to increase smallholder farmer access to effective storage technologies to improve income and food security.

The goal of reducing PHL should be an outcome of increasing smallholder farmers' incomes and food security through access to more effective storage technologies where access means both physical availability and financial capacity to purchase these technologies.

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Paper Number: 1005

Ex-Ante Analysis of the Demand for New Value Added Pulse Products: A Case of Precooked Beans in Uganda.

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In Uganda, common beans (*Phaseolus vulgaris*) are traded without much processing imposing high fuel requirements and extended cooking time on consumers. This constrains bean intake and threatens their future importance in nutrition especially among urban dwellers and consumers that demand for easy to prepare foods. Using the public private partnership approach, efforts are ongoing to introduce fast cooking (precooked) beans as a strategic intervention. This study used the choice experiment approach to investigate potential consumer demand and valuation of precooked bean product attributes (cooking time, fuel saving, nutritional enhancement, cooking water requirement and price). Data was collected from 558 randomly selected households from urban and rural parts of central Uganda and a five class latent model was used to investigate heterogeneity in consumer attribute preferences and to profile consumers. Although all attributes seemed important, there were two dominant classes that comprised 79.7% of the household consumers. In these, demand for nutritional enhancement was greatest followed by low cooking-water requirement and fuel saving. Price negatively affected demand. Urban and small sized households showed higher probabilities of consuming precooked beans probably because they face higher per capita fuel costs and require convenience. In larger households, lower cost per person of boiling dry beans could be the demotivation to demand for precooked beans. These results have implications in market targeting, product design and pricing. They reveal that precooked beans can increase bean consumption thus serving as a strategic remedy for hidden hunger and healthy eating mostly for children and women of reproductive age.

Key words: Demand, choice experiment, product attributes, latent class model, Uganda.

Paper Number: 1006

A Commodity Corridor Approach to Regional Pulse Trade: A Case of Bean Corridors in Eastern and Southern Africa.

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Integration of smallholder farmers in national and regional value chains remains suboptimal constraining regional trade and investments in pulses. This paper analyzes the bean types and varieties and magnitude of their trade in identifiable bean corridors of Eastern and Southern Africa. Data was collected in 7 countries in on 876 traders. Multi-stage sampling procedures were used to select trading points, markets and traders. Data was analyzed through correlations, and probit model to evaluate factors contributing to the observed trade. Results indicate that men dominate the bean transportation while women dominate retail sector. Almost 100 bean varieties are traded in the region, but only 10 types account for 97% of the trade. Profit margins reach 54%, an indication of inefficiencies in bean marketing system and depend on trader type, country and bean type/variety and quality of beans. Informal cross border bean trade account for about 92% of the bean traded, which easily escapes official statistics. The probability of participating in informal bean trade increases by 6% when men are involved as opposed to women, and that an increase in quantities of beans would lower informal trade by 1%. Where customs documentation and levies are perceived to be higher, the informal trade would increase by 11%. Mainstreaming disaggregated pulse data collection will accurately estimate the trade and design policies that support investments in pulse intensification areas (corridors) and enhance cross border trade. Use of a commodity corridor approach to improve business environment for pulse farmers and private sector investors is recommended.

Key words: Bean corridors, Beans, Trade, Informal cross border trade

Paper Number: 1007

The Formal and Informal Cross-Border Trade of Common Beans Between Kenya and Its Neighbours.

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Multi-directional cross-border trade exist in the East Africa region The objective was to Estimate the status of cross-border trade of the common bean. Purposive, multistage and systematic random sampling methods were used to select the 150 respondents for the study. The selected border points included Malaba, Namanga, Busia and Isebania. From the survey results, cereals are traded at the highest proportion (62 %) among the staples followed by pulses (21%). Most of the commodities crossing into Kenya originate from Uganda (maize, beans, sorghum and millet) and Tanzania (beans and rice). Survey results revealed that over 90% of retailers surveyed were adults, about 23% women and 70% of men. Approximately 70% of retailers surveyed were residents of border towns, with only 5% living in towns nearby (10km from the border). Majority (93%) of these traders were literate. The key players included Retailers (31.8%); Wholesalers (10.6%); retailer wholesalers (13.6%); and transporters (22%). Costs involved (handling, packaging and transport; the storage and rental costs; labour costs); housing and feeding costs of the trader and expenses related to the risks involved in trading operations. In general, all transaction costs represent on average 30% and 22% of the selling price of a kilogram of beans on the market. On the cross-border markets, there existed a multitude of local measures units, hence need to harmonize local measurement units in the various border markets. We recommend Elimination of internal customs duty, quantitative restrictions on entry and exit of goods.

Paper Number: 1008

Shedding Light on the “Invisible Middle” of Value Chains for Common Beans in Uganda and Kenya.

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Much of the empirical evidence produced by researchers on African agri-food value chains originates from either farmers or consumers. Scant evidence, about the myriad of small and medium enterprises (SMEs) that link farmers to consumers across Africa, fosters uncertainty among investors and policymakers and tend to mislead their interventions in agri-food value chains. In particular, this study aims to shed light on the “invisible middle” of domestic value chains for common beans in East Africa. We carried out a “stacked” survey, based on “snowballing” sampling techniques, and collected data on 350 interconnected SMEs, mostly represented by retailers, wholesalers and traders operating in and around the four major urban areas of Uganda and Kenya. Our findings counter conventional wisdom that “traders or middlemen” exploit farmers, that product losses along African value chain are substantial and that women are less likely to participate in and benefit from agribusiness activities. Our findings also challenge the standard view of value chains as a linear or vertical process, emphasizing the importance of networks, alliances or horizontal relationships among similar SMEs within each and every segment of the chain. Yet, our findings confirm the widespread perception that quality management remains extremely poor along bean value chains and that contamination - especially by pesticides and chemical residues - represents a major hazard for consumers’ health.

Finally, the study proposes a set of potential interventions to improve the socio-economic and nutritional value generated by SMEs, as well as further research to evaluate these interventions and scale up successful ones.

Paper Number: 1009

Comparison of Cowpea and Groundnut Haulm Trading in Urban and Rural Fodder Markets in Niger.

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A survey was conducted in rural and urban fodder markets in Niger to better understand trading and pricing of cowpea and groundnut haulms. Prices and haulm samples were collected on fortnightly basis for a period of one year from July 2014 to June 2015 from two rural (Gazaoua and Kollo) and two urban (Niamey, Maradi) markets. The haulm samples were analyzed for nitrogen, neutral (NDF) and acid (ADF) detergent fiber, acid detergent lignin (ADL), in vitro organic matter digestibility (IVOMD) and metabolizable energy content. Data were analyzed using ANOVA. Cowpea haulms (average 160 CFA/kg) were sold consistently at higher prices than groundnut haulms (120 CFA/kg). Cowpea haulm quality fodder quality traits were consistently superior to those of groundnut haulms. Sales prices at urban markets were about twice that at rural markets. Average price ratio of: cowpea grains to haulms were 2.4:1 while groundnut grain to haulms ratio was 4.0:1. Haulm prices were lowest after harvest. Farmers can make significant additional income from selling of cowpea, groundnut haulms and cowpea and groundnut breeder should pay attentions to haulm yields. The high price premium of cowpea relative to groundnut haulm suggest that attention should also be given to haulm fodder quality.

Paper Number: 1010

Sequencing of Common Bean Genotypes Provides Comprehensive Resources for Genetic Introgression Studies and Molecular Breeding.

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In this work we present the main results of our efforts to use whole genome sequencing (WGS) and genotyping by sequencing (GBS) data from CIAT elite bean varieties (*P. vulgaris*) and two sister species (*P. coccineus* and *P. acutifolius*), as a rich data resource to detect gene introgressions in to this crop. Our work is motivated by the fact that bean is the most important grain legume for direct human consumption, especially among resource limited smallholder farmers in Latin America and Africa. Sequencing of 500 elite bean varieties of as well as two sister species provided a dataset of about 1.7 million genomic variants. Sequencing of sister species considered to hold valuable alleles for the improvement of common bean allowed to identify introgression blocks of alleles related with resistance to biotic and abiotic stresses. Moreover, correlation between alignment rates and nuclear genome content provided insights in the amount of species-specific genomic content that could be mined in breeding programs. We further evaluated the use of these novel data set of genetic polymorphisms in introgressions lines to detect the genome regions with a higher chance to recombine with the sister species.

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We believe that this study is a major step towards the effective use of WGS and GBS data for marker assisted breeding in common bean. We are continuously using the information provided by the genomic database assembled in this work in the design of SNP markers for traits not only related to resistance to biotic stresses but also for resistance to drought and heat, biofortification and cooking time. We expect that the variation information and allelic patterns delivered in this study will become a foundation for collaborative sequencing efforts among different bean geneticists around the world.

Paper Number: 1011

Genomewide Association Analysis for Drought Tolerance and Associated Traits in Common Bean.

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A genome-wide association study (GWAS) was conducted to explore the genetic basis of variation for drought tolerance and related traits in a Middle American diversity panel comprised of 96 common bean (*Phaseolus vulgaris*) genotypes. The panel grown under irrigated and rainfed conditions and single nucleotide polymorphism (SNP) data was used to explore genetic diversity and ancestry of the diversity panel and discovered varying levels of admixture and purity as well as distinctly divergent individuals. Estimations of genomewide heterozygosity revealed that, on average, greater diversity is present in individuals from race Mesoamerica (3.8%) ancestry, followed by admixed individuals (2.3%). Race Durango had the lowest level of heterozygosity (1.4%). We report 27 significant marker-trait associations based on Best Linear Unbiased Predictors (BLUPs).

Associations include seven markers for shoot biomass at harvest under irrigated conditions and five markers under rainfed conditions on chromosome Pv11, two markers for shoot biomass at flowering under irrigated conditions on Pv02 and Pv08, two markers for seed size under irrigated and rainfed conditions on Pv09, seven markers for lodging score under irrigated conditions on Pv02 and Pv07, one marker for leaf elongation rate on Pv03 and one marker for wilting score on Pv11. Significant QTL identified in this study could potentially be used in marker-assisted breeding to accelerate genetic improvement of drought tolerance common bean.

Paper Number: 1012

Genome Resources for Cowpea and Their Application to West African Breeding Programs.

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Cowpea is a primary source of protein for millions of people in Sub-Saharan Africa and other parts of the developing world. Cowpea is a warm season legume along with soybean and common bean, although it is more drought and heat tolerant than most of its legume relatives. Despite its relevance to agriculture in the developing world and its stress resilience, genome resources lag behind other major crop plants. Such resources would enable critical advances in the exploitation of cowpea germplasm for gene discovery, marker development and fine mapping of agronomic traits. Using the recently developed Illumina iSelect SNP genotyping assay for cowpea, we have genotyped five biparental RIL populations and developed a consensus genetic map containing 37,372 SNPs mapped to 3,280 bins. This map has been used as a framework for eleven pseudomolecules that includes a whole-genome shotgun (WGS) assembly of IT97K-499-35 and sequences from about 3,500 minimal tiling path BACs. These resources have been utilized to examine a set of West African breeding materials. We have determined the genetic relationships between them and we have defined the patterns of polymorphism across the eleven chromosomes, revealing genomic regions where genetic diversity is depleted. The new genome resources presented here will help accelerate the breeding of new cowpea varieties to address food security issues in the face of limited-input farming and climate stress. The lack of genetic diversity in certain genomic regions found within the West African cowpea population could be the result of selection during domestication and/or breeding.

Paper Number: 1013

A Multiparent Advanced Generation Inter-Cross Population for Genetic Analysis and Breeding in Cowpea (*Vigna unguiculata* L. Walp.).

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Development and analysis of Multiparent Advanced Generation Inter-Cross (MAGIC) populations have been conducted with several crop plants due to the potential for dissecting the genetic structure of traits and improving breeding populations. As part of the Tropical Legumes I Project (GCP-funded, 2009-2015), we developed an 8-parent MAGIC population for cowpea (*Vigna unguiculata* L. Walp.).

The 8 founder parents (IT89KD-288, IT84S-2049, CB27, IT82E-18, SuVita 2, IT00K-1263, IT84S-2246, and IT93K-503-1) are highly diverse and carry many abiotic and biotic stress resistance, seed quality and agronomic traits relevant to cowpea improvement in sub-Saharan Africa. They were inter-mated using structured matings to ensure a population would have equal representation from each of the founder parents, followed by single-seed descent, resulting in more than 300 F8 recombinant inbred lines (RILs) each carrying a mosaic of genome blocks contributed from all founders. This was confirmed by SNP genotyping with the Illumina 60K iSelect as part of the Feed the Future Innovation Lab for Climate Resilient Cowpea. The F8 lines were on average 99.74% homozygous while also diverse in disease resistance and morphological traits including growth habit, flower color, flowering time, maturity, leaf shape, pod load, and seed size, shape, color and texture, and stay-green under drought.

Due to its broad genetic base, the cowpea MAGIC population promises breakthroughs in genetic gain, QTL discovery, and construction of high-resolution genetic maps for use in haplotype-trait definition and genome assembly.

Paper Number: 1014

A Bt Gene Effectively Controls Maruca Pest in Cowpea.

PRINCE ADDAE, African Agricultural Technology Foundation*

Title: A Bt gene effectively controls the maruca pest in cowpea

Authors: Addae, P.C., Huesing, J. Onyekachi, F., Bationo, J., Abudulai, M., Ishyaku, M., and Higgins, T.J.V.

Maruca vitrata accounts for yield losses of 20 to 80% in cowpea in SSA (IITA, 1984). Without the availability of resistant varieties, farmers regularly spray 5-8 times within a season, to obtain 150-300 kg/ha as against the potential yield of 1500-2000 kg/ha. The Pod-borer Resistant (PBR) Cowpea Project was initiated to control the maruca pest through the use of the Bt gene, Cry1Ab obtained royalty free from Monsanto Company. Efficacy trials have shown 98-99% reduction in pod and seed damage from maruca pest in confined field trials (CFT) in Nigeria and Burkina Faso with artificial infestation over several years starting in 2010. The Cry1Ab gene has been incorporated into farmers' preferred varieties through conventional breeding. The first variety, PBR Cowpea-1 was tested in Nigeria, Ghana and Burkina Faso and confirmed near complete Maruca pest control with estimated yield increase of over 20% per plot in CFTs. Homozygous BC5F6 seed has been produced for release to farmers. Efforts are underway to incorporate a second Bt gene (Cry2Ab) into this new variety for integrated resistance management (IRM).

Paper Number: 1015

Transforming Crop Breeding at Monsanto How Relevant to Crops in Africa.

Roy G. Cantrell, Monsanto Company - USA*

The focus of Monsanto Breeding is to increase genetic gain and protect productivity of six crops globally. This is built on a base of extensive genetic diversity that can be harnessed with new genomic and data technologies. These integrated systems enabled accelerated improvement in key plant health traits. The application of Genome Wide Selection permits scaling of breeding programs. Layers of data require interconnected analytics to enhance decision making in breeding programs. The extensive data collected on products in the pipeline not only support better product advancement but provides valuable data on products released to support decisions by the customer. Commercial plant breeding continues to undergo transformation that will overtime have a global impact across multiple crops. Lessons from this Global Breeding program can be applied to Tropical Legumes in Africa.

Paper Number: 1016

Applying Next-Generation Sequencing to Enable Marker-Assisted Breeding for Adaptive Traits in a Home-Grown Haricot Bean (*Phaseolus vulgaris* L.).

Andrew Tock and Eric Holub, University of Warwick*

Our research applies next-generation sequencing to establish molecular breeding capability for adapting haricot bean (*Phaseolus vulgaris*) to the UK climate. Pre-breeding material is being exploited to enable genetic mapping and marker-assisted selection of essential adaptive traits, including: 1) resistance to seed-borne pathogens; 2) root architecture related to abiotic stress tolerance and nutrient acquisition; 3) early harvestability; and 4) seed nutritional, morphological and cooking characteristics of consumer interest. We are pursuing a candidate-gene approach to genetic marker development, informed by the crop ideotype, using RNA-seq and genotyping-by-sequencing databases of SNP and INDEL variants generated for UK-adapted varieties. A primary objective is to derive a high-resolution genetic map for a biparental recombinant inbred population (small white navy × large brown kidney). The map will include polymorphic markers generated for previously described adaptive genes. This genetic map will be used to investigate the molecular basis of race-nonspecific resistance to halo blight, caused by *Pseudomonas syringae* pathovar *phaseolicola*. Previous reports indicated simple recessive inheritance of this resistance. In our experiments, the resistance segregated amongst inbred lines as a continuous spectrum of resistance and susceptibility following inoculation with two races of the pathogen. These results suggest that the resistance may be a quantitative trait governed by multiple genetic factors. Further work is underway to characterise phenotypic variation within inbred populations upon challenge with additional races of the pathogen. Combined with genotyping-by-sequencing data, these phenotype data will be used for genetic mapping of potentially durable race-nonspecific resistance to an important disease constraint on global bean production.

Paper Number: 1017

Breeding Management System for Grain Legumes Research.

Trushar Shah, IITA*

The Breeding Management System (BMS) is a suite of interconnected breeding software tools and related databases specifically designed to help breeders with project planning, data management, statistical analysis and decision-making in their integrated plant breeding programmes. The software is freely available to scientists from public institutions in Africa (www.integratedbreeding.net). This presentation will cover the salient features of the Breeding Management System and will showcase examples of resources available for the various grain legume crops that have adopted the BMS. The databases integrate genealogy, phenotypic and genotypic data as well as analytical and decision support tools.

Paper Number: 1018

Community Readiness to Address Food Security and Evaluation of Cowpea Intake of Weaning Infants in Dioro, Mali.

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Cowpea (*Vigna unguiculata*) is the most important food legume grown in the tropical Savanna zones of Africa. It is a highly suitable crop because of short growth cycle, and it matures early. Cowpeas are consumed during the end of the rainy season when food becomes extremely scarce, particularly in the Sahel regions, such as Mali. One of the Millennium Development Goals (MDGs) target was to control malnutrition among children less than 5 years old, and Mali is among the 48 African countries with high prevalence of malnutrition and diarrheal disease. We completed an assessment of community readiness to improve food security and reduce childhood diarrheal diseases. This project collected qualitative data from a diverse set of community members residing in Dioro, Mali. The Community Readiness Model (CRM) was used to develop two questionnaires to address and describe a community's interest and willingness to try new prevention strategies, including local, staple food nutrition.

These interviews provide baseline information on this community's knowledge and efforts to reduce childhood diarrheal disease and enteric dysfunction associated with stunting, as well as on improving food security. Additionally, these results can be used towards research efforts to determine appropriate interventions incorporating legume and cowpea components. We have assessed if cowpea, among other grains and local foods is being consumed during the infant weaning period, and utilized dietary questionnaires completed monthly by mothers and community health workers to determine how often and at what age weaning infants (ages 6-12 months) consumed cowpeas in the community of Dioro. This data was collected from 50 families residing in Dioro, and is part of information collected from our Pilot Dietary Supplementation Clinical trial (NCT02557373). This prospective data collection will provide insight on current weaning behaviors/patterns that includes cowpea intake for infants and their families in rural Mali. These studies were conducted under protocols approved by the human institutional review boards at CSU and USTTB, and this work was supported by a Grand Challenges Exploration Phase II grant from the Bill and Melinda Gates Foundation.

Paper Number: 1019

Constraints of Bean Consumption Among the Base of Pyramid (BoP) Consumers in Urban and Peri-Urban Kenya.

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Globally, 45% of under-five mortality is attributable to undernutrition. In Kenya, 26% of children under five years are stunted, and this is particularly high in urban slums at more than 40%. Consumers at the base of pyramid (BoP) are unable to access adequate amounts of nutrient-dense foods to meet their dietary requirements. They therefore subsist on monotonous staple-based diets. Increased utilization of nutrient-dense foods, such as beans, would contribute in alleviating malnutrition especially among the poor consumers. Beans are a key source of protein among low income households. We carried out a study amongst 350 BoP consumers in urban and peri-urban of Nairobi to find out the major constraints of bean consumption among children under five years, and women within the reproductive age. The sample households were stratified by social economic status and instrumental variable approach is used to undertake the analysis. Results show that 98% of the sampled households consume beans, although over 50% consume beans only once a week. About 20% of the households consume less beans than they would have desired. When asked factors that constraint bean consumption, 63% indicated that beans are expensive (selling for about 0.86 US dollars per kilogram). High fuel cost and long cooking time were also cited by more than 30% of the respondents to limit their quantity of bean consumption. Coming up with affordable bean based products that take a short time to cook would increase bean utilization hence contribute in reducing malnutrition among the BoP consumers.

Paper Number: 1020

Impact of Legumes Vs Corn-Soy Flour on Environmental Enteric Dysfunction and Stunting in Rural Malawian Children: Randomized, Investigator-Blinded, Prospective Clinical Trial.

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Stunting is common in Africa and has lifelong effects. Environmental Enteric Dysfunction (EED), an idiopathic and asymptomatic chronic inflammatory state of the gut is associated with stunting. EED is in >80% of children in rural Malawi. Given failures of prior interventions against EED, legume-based complementary food that have shown to be anti-inflammatory which can decrease the effects of chronic inflammatory state associated with EED should be tested. Here we report a trial designed to explore the effectiveness of legume-based complementary food in reducing or reversing EED and stunting. Healthy children (two cohorts; 6-11 months old and 12-24 months old) from two rural villages at high risk of EED and stunting are randomized to legume-based complementary food made from cowpeas, common beans, or corn soy blend (control group), a traditional Malawian complementary food. Before intervention, a dual sugar permeability test (lactulose-mannitol test) is performed. Younger cohort is followed up for 6 months and older cohort for 12 months. Primary outcomes include changes in EED marker (lactulose: mannitol ratio) and changes in height-for-age Z-score (HAZ). So far the older cohort has 296 children, 53% male, mean age 17.5 months, 32% stunted (HAZ<-2). 173 have been recruited in the younger cohort, 53% male and mean age of 5.2 months, 13% stunted (HAZ <-2). By the conference time data on nutritional status changes after follow-up will be available.

Results will provide critical information regarding effectiveness of legumes against EED which will reduce the burden of stunting among Malawian children.

Paper Number: 1021

Role of Pectic Polysaccharides in the Development of the Hard-to-Cook Defect in Common Beans (*Phaseolus vulgaris*) during Storage.

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Importance of legumes in addressing food insecurity and protein energy malnutrition cannot be underestimated. However, effective utilization of legumes is hampered by the development of the hard-to-cook (HTC) defect especially under tropical storage conditions. This is due to prolonged cooking times associated with hardened seeds leading to increased energy costs. Several hypotheses to explain the occurrence of the HTC defect have been postulated among them involvement of pectin.

This research aimed at gaining mechanistic insights into the role of pectic polysaccharides in the development and manifestation of the HTC defect in common beans (*Phaseolus vulgaris*). Pectic polysaccharide properties determined included extractability in different solutions, galacturonic acid and neutral sugar content, degree of methoxylation (DM) and molar mass distribution. Pectic polysaccharides were fractionated into water, chelator and Na₂CO₃ extractable pectin and a hemicellulose fraction. Spectrophotometric methods were used for determination of galacturonic acid while high performance anion chromatography and high performance size exclusion chromatography coupled with multi angle light scattering and refractive index detection were used for neutral sugars and molar mass analysis, respectively. The results revealed highly branched pectin with low DM (

Paper Number: 1022

White Tepary Bean Shows Higher in Vitro Iron Bioavailability Than Brown Tepary or Common Bean.

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Iron deficiency anemia is the most prevalent micronutrient disorder globally, especially in populations who consume mainly plant-based diets. Although beans contain a greater amount of iron in comparison to wheat, corn or other staple crops, the bioavailability is often low due to inhibitory factors like polyphenols and phytic acid. Tepary beans (*Phaseolus acutifolius*) thrive better in arid climates than other beans, making them a suitable crop for expansion into marginal ecological zones with climate change. Iron bioavailability is unknown for many tepary varieties, but proximate analysis shows higher iron content than in most common bean (*Phaseolus vulgaris*) varieties. The study purpose was to determine in vitro iron bioavailability, proximate analysis, polyphenol, and phytic acid content of tepary and common bean varieties. Increased iron bioavailability in a bean with arid climate resiliency can offer a sustainable solution towards reducing iron deficiency anemia in developing countries. Whole seeds of 5 tepary white, 3 tepary brown, 4 black, and 2 pinto bean varieties were analyzed. Polyphenol (PP) and phytic acid (PA) extractions were assessed colorimetrically. Iron concentrations were determined using ICP-mass spectrometry following a microwave digestion. Iron solubility analysis was completed through in vitro digestion of the cooked beans. Supernatants from the in vitro digestion were used in determining the iron bioavailability through a CaCo-2 cell culture model. For statistical analysis, results were pooled by tepary white, tepary brown, black bean, and pinto bean. Both tepary white and tepary brown groups showed significant differences in PP content in comparison to the black and pinto ($p \leq 0.05$), whereas PA, amongst all groups, showed no significant differences ($p > 0.05$). Iron content ranged from 29.8 g/g to 78.47 g/g, with pinto beans having significantly lower iron concentration (mean = 33.64 g/g). Significant differences in percent solubility were found between the pinto bean and tepary varieties ($p \leq 0.05$), but not the black. Iron bioavailability of the tepary white showed a negative correlation with PP content (high iron, low PP). The tepary white showed significantly higher iron bioavailability ($p \leq 0.02$) in comparison to both pinto and black beans. Our data suggests that the low PP and PA contributes to higher iron bioavailability in the white varieties of *Phaseolus acutifolius*. Further studies to replicate these findings are needed, followed by clinical testing of tepary white iron bioavailability in humans.

Paper Number: 1023

Field Evaluation of Nutritionally Superior Common Bean Genotypes with Farmers in Three Agro-Ecological Zones in Uganda.

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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 several micronutrients. The efficacy of biofortified crops to address human malnutrition can further be improved if genotypes with highly bioavailable minerals are developed. Genotypes with high iron and zinc concentrations, and high iron bioavailability were identified from a set of a diverse Andean bean germplasm using an in-vitro CaCo-2 cell line assay. A subset of 23 genotypes that are nutritionally superior were identified and have been evaluated in the farmers' fields along with local check genotypes in a participatory variety selection approach using a mother-baby trial design. Nine farmer groups each comprised of about 40 farmers participated in the field research. The farmers are from districts representing three agro-ecological zones in Uganda that are important in both dry bean production and consumption. We will present data on socio-economic aspects of the participating communities and results from participatory appraisal of the key bean variety improvement traits according to the farmers' rankings. Also, data on genotype tolerance to incidences of several bean foliar diseases, and yield components as well as genotype-by-location interactions for both foliar diseases and yield will be presented. Based on the data from this 2015 field trial, nutritionally superior genotypes exhibiting good adaptation to the Ugandan bean production conditions and are preferable to the farmers and consumers will be highlighted and recommended for release.

Paper Number: 1024

Can We Breed Pulse Crops to Improve Human Health: An Emerging Facet in Contemporary Crop Improvement.

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Pulse crops are known as important sources of protein, mineral nutrients, essential vitamins, dietary fiber and other phytochemicals in the human diet. These compounds have dietary health implications, including lowering blood pressure, reducing the risk of advanced colorectal cancer, obesity, diabetes and cardiovascular disease. Pulse crops also contain high levels of dietary fiber and oligosaccharides that are also known to enhance human health. Research at the Crops for Health program at Colorado State University and at North Dakota State University was initiated to better understand the effect of pulse crops on reducing the incidence and severity of chronic diseases and the genetic control of dietary fiber in common bean (*Phaseolus vulgaris* L.). Preclinical and genomic studies have been conducted to elucidate mechanisms and genetic control for traits that contribute to reducing the incidence of obesity, heart disease and cancer. Studies on dietary fiber content of common bean used Genome Wide Association Studies to map genomic regions responsible for soluble and insoluble dietary fiber, and oligosaccharides. GWAS coupled with whole genome sequence data led to candidate gene discovery for soluble and insoluble dietary fiber content and oligosaccharide content. Future implications of breeding for healthy pulse crops will be discussed.

Paper Number: 1025

Changes in Protein, Phenolic and Condensed Tannin Contents of Cowpea Mutants from Irradiated Cowpea Parents.

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The need for higher contents of proteins and other health promoting compounds in foods that the populations already consume cannot be overemphasized for developing nations. To investigate the effects of gamma irradiation on protein, phenolic and condensed tannin contents, three parent cowpea (*Vigna unguiculata* (L) Walp.) varieties from Zambia were gamma irradiated, planted and selected successively up to beyond the seventh mutant generation (M7). Lutembwe, Bubebe and M'sandile cowpea parent seeds had eight, six and four mutant lines, respectively. Laboratory analyses revealed that the crude protein of Msandile, Lutembwe and Bubebe cowpea parent seeds ranged between 23.5 and 25.6%, db. All the Lutembwe mutant lines except one had statistically higher crude protein contents ($p < 0.05$) than their parent, while only two had higher contents in Bubebe and M'sandile had none. The total phenolic contents of the three parent cowpeas ranged between 14.4 and 17.2 mgCE/g, db, and all of them had only one mutant line each with a significantly higher phenolic content ($p < 0.05$) than their parents. The condensed tannins of the three parent cowpeas ranged between 64.0 and 140.8 mgCE/g, db). All the Bubebe mutant lines, except one, had significantly higher ($p < 0.05$) condensed tannin contents than their parent, while only one mutant line was recorded for M'sandile mutant lines and the Lutembwe had none. It appears that gamma irradiation of parent cowpea varieties generally leads to an increase in crude protein and condensed tannin contents of their mutant lines, while it leads to a reduction in phenolic contents in their mutant lines.

Key words: Cowpea, Gamma Irradiation, Protein, Phenolic, Condensed Tannins

Paper Number: 1026

Farmer Decision Making Strategies for Improved Soil Fertility Management in Uganda and Mozambique.

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Poor and declining soil fertility is a key constraint to common bean productivity among smallholder farmers in Africa who manage complex, multifunctional cropping systems. Use of improved crop management practices and technologies, particularly regarding soil fertility, could sustainably increase crop yields and improve food security and farm income; however, their use is modest for common beans. We aim to understand and enhance farmers' decision-making strategies through action research. We analyze data from baseline surveys conducted in mid-2014 among smallholder households with rainfed maize-bean cropping systems in southwest Uganda (n=302 in Masaka and Rakai districts) and northern Mozambique (n=305 in Gurué district). We examine key factors that explain differences in crop management practices (rotation, fallow, intercropping, experimentation, etc.) and use of technologies (organic and inorganic inputs). Proximate determinants are awareness, availability, access and affordability of the technologies. Farmer decisions are shaped by opportunities and incentives, and moderated by the level of resource ownership and access, labor hiring practices, market sales, and social and economic networks. Our team is supporting the development of multistakeholder bean Innovation Platforms.

Paper/Poster Abstracts

Members engage in field experiments that test and demonstrate the impact of various management practices and technologies, strengthen social cohesion, and stimulate interest among others in learning from trials and demonstrations. This stimulates improved bean productivity and marketing through collective action. We are developing visual decision support aids and examining the efficacy of methods for dissemination, training and support. Keywords: beans, soil fertility, decision-making, action research, Uganda, Mozambique

Paper Number: 1027

Maize-Common Bean Intercrop Productivity As Affected By Planting Arrangements and Applied Nutrients in Northwestern Ethiopia.

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Maize (*Zea mays* L.) and common bean (*Phaseolus vulgaris* L.) intercropping is an important recently emerging cropping system in Northwestern Ethiopia which can be improved with better information on planting arrangements and nutrient management. Field experiments were conducted in Northwestern Ethiopia during the 2012 and 2013 crop growing seasons to determine the combinations of planting arrangement and N and P rates for optimizing maize-common bean intercrop productivity and profitability. The treatments consisted of two intercrop planting arrangements (IPA), two N rates, and two P rates arranged in a complete factorial RCBD with three replications. Sole crop maize and sole crop bean were additional treatments. Results indicated that land equivalent ratio was more than unity, and the intercrop system was 20% more productive relative to the sole crop. Equivalent yields of maize were highest for the intercrop treatments relative to the sole crop maize with yield advantage of 14% from single row IPA with 128/20 N/P kg ha⁻¹. Single row IPA with 128/20 N/P kg ha⁻¹ and paired row IPA with 92/20 N/P kg ha⁻¹ increased monetary advantage by 16 and 8%, respectively, relative to sole crop maize. Smallholder maize-based cropping system of Northwestern Ethiopia could be nutritionally, agronomically and financially improved through maize-common bean intercropping of single row IPA with 128/20 and paired row IPA with 92/20. Maize-common bean intercropping can be further maximized by optimizing N requirements of common bean to minimize belowground intercrop competition and enhance complementarity with maize. Key words/phrases: Equivalent yield of maize; Land equivalent ratio; *Phaseolus vulgaris* L; Profitability; *Zea mays* L.

Paper Number: 1028

Developing Conservation Agriculture in Maize Legume Systems for Small Holder Farmers in Zambia, Malawi and Mozambique - a Beneficiary Perspective in Zambia.

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Conservation agriculture (CA) one of the sustainable intensification practice that is promoted by various organizations and governments of southern Africa to overcome the problem of soil degradation, drought, low and unstable crop yields and high production costs was tested through on-farm experiments for integrating legumes in conservation agriculture (CA) maize based systems in Monze, Mpongwe and Chipata districts during the 2014/15 agriculture season by the Zambia Agriculture Research Institute based in Choma, southern Zambia. The objectives were twofold; (i) to develop and validate best CA practices that will reduce risk in smallholder farming systems; and (ii) to build capacity of farmers, extension workers and other partners in implementing CA oriented technologies. The experiments were set up in a randomized complete block design with eight treatments replicated three times across the research sites; pigeon pea + maize + 200kg/ha fertilizer; pigeon pea + maize + D- compound fertilizer 200kg/ha; pigeon pea + maize + 100kg/ha fertilizer; cowpea + maize + 200kg/ha fertilizer; cowpea + maize + D- compound fertilizer 200kg/ha; cowpea + maize + 100kg/ha fertilizer; maize/cowpea rotation and farmer practice. In Chipata and Mpongwe districts cowpea was replaced by groundnuts and soybeans respectively. Preliminary results revealed that intercropping of cowpea and maize with application of D- compound fertilizer @ 200kg/ha produced better maize yields (4.5t/ha) than with groundnuts and soybeans (1.6t/ha and 3.2t/ha respectively).

We preliminary concluded that for CA oriented technologies to be taken up by farmers in Zambia there is need to strengthen the research, extension and farmer linkages

Paper Number: 1029

Response of Cowpea to Different Integrated Nutrient and Water Management Technologies in the Southern Rangelands of Semi-Arid Eastern Kenya.

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The Southern Rangelands of Kenya are difficult environments prone to frequent droughts. The effect of the flat (farmer practice), tied-ridging and contour furrows water harvesting technologies (seedbed types) and five integrated nutrient management practices on the performance of rainfed cowpeas was studied on-farm at the southern rangelands of Kenya during the short rains season which fall between October and December.

Cowpea grain yield responded positively under manure at 10t ha⁻¹ irrespective of the water harvesting technology (seedbed) type. There was a negative effect on cowpea grain yields on addition of inorganic fertilizers. The highest cowpea grain yield was recorded in the treatments without inorganic fertilizers. It was generally observed that the highest grain yield was observed under manure applied at 10t ha⁻¹ irrespective of seedbed type. Another general observation made was that the tied-ridging seedbed type produced higher cowpea yield than contour furrows and flat seedbeds irrespective of the soil fertility option applied. Tied-ridging and contour furrows water-harvesting technologies (seedbed types) applied together with manure at 10t ha⁻¹ produced significantly higher yields than those under the (farmers practice) flat seedbed. As such, if farmers are willing to apply manure at 10t ha⁻¹, it is upon them to make a choice between the two seedbed types depending on the economic implications of their preparation. In the absence of any soil fertility application option, the tied-ridging water harvesting technology should be recommended to farmers in the Southern Rangelands of Kenya.

Paper Number: 1030

Crop and Intercrop Combination, Tillage and Fertilizer Treatment Effect on Green Grams Performance in the Semi-Arid Southern Rangelands of Kenya.

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Crop failures are frequent in Kiboko in semi-arid rangelands of Kenya that is characterized by unreliable and poorly distributed low rainfall. There is a need to promote drought tolerant crops such as green grams that yield reasonably with little rainfall, are highly marketable, fetch a premium price, and contributes to resilience and livelihoods of farmers. Pre-tested integrated soil fertility and water management technologies in the productivity of green grams with a view to promoting their use in semi-arid Makueni County were validated.

Green grams grown under Tied Ridges + Sila/Green Gram Intercrop + 40N + 40P, Tied Ridges + Sila/Green Gram Intercrop + 20N + 20P, Flat Seedbed + Green Gram + Nil Fertilizer, Flat Seedbed + Sila/Green Gram Intercrop + Nil Fertilizer treatment combinations produced significantly high grain yields. Green grams grown as a monocrop under flat seedbed (0.38 T/Ha) performed significantly better than the crop under the tied ridges (0.15 T/Ha). However, when intercropped with either Macia or Sila varieties, those grown under tied ridges performed significantly better than ones under flat seedbed. Green grams intercropped with Sila (0.37 T/Ha (Flat) and 0.47 T/Ha (Tied Ridges) produced significantly higher grain yields than those intercropped with Macia (0.19 T/Ha (Flat) and 0.25 T/Ha (Tied Ridges) irrespective of tillage system used. Green grams intercropped with sorghum under tied ridges performed significantly better than ones under flat seedbed. Green grams performed best without fertilizers when grown as a monocrop under the flat tillage system.

Paper Number: 1031

Effect of Integrating Organic with Inorganic Fertilisers on Bean Yield on Three Contrasting Soils.

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Common beans (*Phaseolus vulgaris* L.) constitute the most consumed grain legume, contributing 45% of the protein intake in Uganda. Unfortunately, of the 75% (1400 kg/ha-1) yield gap observed between research and smallholder farms, 30% is attributed to soil fertility, mostly N and P limitations. Available recommendations of 15 kg/ha-1 N and P or 5.0 t manure/ha-1 applied as sole inorganic or organic are still high for smallholders and are not soil specific. The objective of this study was to establish suitable combinations of chicken manure, N and P for bean production on three different soils of Masaka district, Uganda. The experimental design was split plot RCBD with N and P each at 0, 7.5, 15 kg/ha-1, and poultry manure (0, 2.5, 5 t/ha-1) in a complete factorial applied on three soils: Phaeosem, Cambisol, Umbrisol. Combined application of organic and inorganic was superior on all soils with best and least grain yield observed on the Phaeosem and Cambisol, respectively. Application of 2.5 or 5.0 t manure/ha-1 with or without N and/or P yielded higher grain bean than sole N and/or P treatment.

Paper/Poster Abstracts

Highest bean grain yield (3338 kg/ha) was on Phaeosem treated with 7.5kg (N+P)/ha+2.5t manure/ha. However, this was not significantly different from the yield on Cambisol treated with 15kg (N+P) /ha+2.5 t manure /ha and Umbrisol treated with 7.5 kg (N+P) /ha+2.5 t manure /ha. Farmers can therefore apply 7.5 kg (N+P) /ha combined with 2.5 or 5 t manure/ha to improve nutrient utilization which suggests for increasing crop-livestock integration.

Key words: common bean, limiting soil nutrients, smallholder farmers, soil types.

Paper Number: 1032

Response of Common Bean (*Phaseolus vulgaris* L.) to Nitrogen and Phosphorus and Rhizobia Inoculation Across Variable Soils in Zimbabwe.

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Soil fertility depletion ranks as the most important drawback to crop productivity in Sub-Saharan Africa. Three on-farm experiments were conducted to explore the effect of nitrogen (N), phosphorus (P) and rhizobia inoculation on common bean productivity in Eastern Zimbabwe. Two common bean cultivars were tested in a split-plot arranged in randomized complete block design. The main plot was the combination of N (0 and 60 kg ha⁻¹) and P (0 and 20 kg ha⁻¹) and the sub-plot were cultivar (Gloria and NUA 45) and inoculation (+/- inoculum). Both N and P were applied at 20 kg ha⁻¹ at planting and an extra 40 kg ha⁻¹ N top dressing.

Number of nodules, active nodules and pods were significantly increased by N and P application. On a degraded site with 0.32% SOC, none of the factors significantly increased grain yields ($P > 0.05$). Yields for control were a paltry 0.21 t ha⁻¹ compared to 0.45 t ha⁻¹ with N, P and rhizobia. Analysis of variance of grain yield for the two sites that had SOC > 0.6% resulted in significant simple effects of N and P, and NP interaction ($P = 0.03$). Grain yields significantly increased from 0.49 t ha⁻¹ (control) to 1.56 t ha⁻¹ at 60 kg ha⁻¹ N and 20 kg ha⁻¹ P. These results suggest that farmers can invest in both N and P for common bean production, but not in acutely degraded soils. Improved common bean cultivars currently on the market barely respond to the local rhizobia inoculum.

Paper Number: 1033

Dynamics of Biologically Fixed Soil N Levels and Its Enhancement in Maize-Legume Cropping Systems in the Northern Guinea Savannah Ecology.

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Prepared for presentation at Joint Pan-African Grain Legume and World Cowpea Conference, 28 February - 4 March 2016, AVANI Victoria Falls Resort, Livingstone, Zambia

Abstract

Maize and grain legumes are food security and poverty reduction tools in Sub-Saharan Africa. Traditional farming systems in the savannah ecologies dominated by cereals have occasioned progressive depletion of soil nutrients and low yield of cereals while cost considerations had constrained widespread application of exogenous soil fertility amendments. Effort to raise the productivity of primed cereals such as maize in the region is increasingly drawing on low cost agronomic inputs adoptable by smallholder farmers and communities where malnutrition remained a challenge. Intercropping cereals with legumes which hitherto increased the productivity of component cereals is proving inadequate in the short runs under the prevailing savannah agro-systems necessitating sustained quest for improvement options. The treatments in the study included a range of maize-legume cropping systems to investigate the stability of biologically fixed N in-between seasons and options (inoculant) for boosting legume induced N enhancement in the alfisols of Northern Guinea Savannah (NGS) ecology. The result showed decreasing trend in the level of soil nitrogen recorded at harvest compared with that recorded seven months later at the start of the following season. As much as 76% reduction in soil N-level was observed in Soybean plots in the first year and 69% in the second year. In cowpea plots, the reduction in N-level was 84% and 82% in the first and second years respectively. Though diversity in varietal responses was significant, maize grain yield was 13% higher when intercropped with soybean than with cowpea in the first two years. In the third year when long season variety of cowpea was used in the maize-cowpea intercrop, maize grain yield of the system was comparable with that of soybean.

In plots sown to soybean seeds treated with nodulation stimulant, the decreasing trend in soil N-levels was similar to those of non-treated seeds. Soil N-level at harvest was higher by 12% and 8% at the start of the following cropping season for plots of soybean treated with inoculant. The study concludes that mechanism of reducing the losses (preserving) of biologically fixed soil N need to be developed in order to optimize the contribution of legumes in cereals-legume cropping systems. The implications of the results on long term soil fertility management and crop productivity are discussed.

Paper Number: 1034

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

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Genetic basis of symbiotic nitrogen fixation (SNF) variability in common bean (*Phaseolus vulgaris* L.) is poorly understood. To understand the genetic architecture of SNF variability in common bean three studies were conducted: (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. QTL mapping study was conducted using recombinant inbred lines (RILs) derived from cross of Solwezi and AO-1012-29-3-3A. Transcriptome profiling study was conducted on two RILs contrasting for SNF that were selected from the Solwezi x AO-1012-29-3-3A population used in the QTL mapping study. GWAS identified significant associations for nitrogen derived from atmosphere (Ndfa) on chromosomes Pv07 and Pv09. The GWAS peak identified on Pv09 for Ndfa 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 genes including Phvul.007G048000 that encodes 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. Once validated, QTL and candidate genes identified in the current study have potential to be used in marker-assisted breeding to circumvent challenges of phenotypic selection for SNF, and accelerate genetic improvement of SNF in common bean

Paper Number: 1035

Cowpea (*Vigna unguiculata*) Crops in Africa Can Respond to Inoculation with Rhizobium.

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Paper Number: 1036

The Type of Indigenous Rhizobia, Rather Than Population Density, May be a Greater Determinant of Inoculation Success in *Phaseolus vulgaris*.

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Phaseolus vulgaris can be nodulated by diverse nitrogen fixing bacteria. This poses a challenge to successful improvement of yields through inoculation of the crop when the applied inoculant strain has to compete with soil resident strains of variable nitrogen fixing abilities leading to sub-optimal performance. Most evidence indicates it is a game of numbers with models developed to predict resident population thresholds that inoculation cannot overcome. In glasshouse experiments using reporter genes to assess nodule occupancy, a commercial bean inoculant strain, *Rhizobium tropici* CIAT 899, was applied on the seed while competing strains were pre-mixed in potted soil at different populations and monitored over the duration of the experiment.

To highlight one result, CIAT 899 on seed (0.7×10^7 cells/seed) overcame a stable population of 106 cells/g of soil of *Rhizobium* sp. NAK 120 to occupy 79% of the nodules but occupied only 1% of nodules when *Rhizobium* sp. NAK 287 was in the soil. It was found that nodule occupancy outcomes depended on the type of strain in the potted soil and less on the numbers in the soil. These findings help explain the hit and miss results experienced in the field with bean inoculation, as they clearly demonstrate the influence of the type of strain resident in the soil, independent of the commonly studied factor - the population numbers. Studies that may emanate from these findings include the identification of the major characteristics of strains that provide the greatest impediment to successful bean inoculation.

Paper Number: 1037

On-Farm Yield Response of Chickpea [*Cicer Arietinum* (L)] to Inoculation and Phosphorus Fertilizer in Ethiopia.

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On-farm yield response of chickpea [*Cicer arietinum* (L)] to inoculation and phosphorus fertilizer application in Ethiopia

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Chickpea is the third most widely cultivated food grain legume in Ethiopia and the country is the largest chickpea grower in Africa with market share of 40% in the continent. Despite its potential yield (>3 ton ha⁻¹) current chickpea productivity is low in Ethiopia (> 1.6 ton ha⁻¹). Chickpea is specific for its rhizobial requirement and phosphorus enhances nitrogen fixation. An on-farm study was conducted to evaluate the response of chickpea to inoculation and P-fertilizer at Damote-Gale in Ethiopia. Four treatments, inoculation with *Mesorhizobium* sp. strain CP 41 (+I), P fertilizer (TSP) (+P) and the combination of both (+P+I) including control (-P-I) were tested on twenty farms. In addition, the MPN count of rhizobial population size in the study site was determined. Analysis of collected data on symbiotic, yield and yield related traits indicated that inoculation and P fertilizer improves nodulation, growth and yield of chickpea. Inoculation, P+ and the I+P+ treatments increased grain yield by 26%, 19% and 33% over the control, respectively. Similarly, the total nitrogen content of the straw increased by 56% and 85% due to inoculation and combined treatment, respectively, thus indicating improved nutritive value of the residues for livestock feed. The population of soil resident compatible rhizobia was very low (< 10 gram⁻¹ of soil), warranting the benefit of inoculating chickpea. The improved performances of chickpea and the benefit to household income due to inoculation and the potential role that it plays in sustainable intensification of crop-livestock system in the target area are discussed.

Key words: Inoculation, P fertilizer, Chickpea, MPN count.

Paper Number: 1038

Symbiotic N₂ Fixation in Field Grown Kersting's Groundnut (*Macrotyloma geocarpum*) Landraces in Response to Inoculation with Bradyrhizobium Sp. in Ghana.

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Kersting's groundnut is an under-utilized grain legume that faces extinction due in part to lack of research to improve the crop. Presently, reports on the amounts of N-fixed by the crop via the legume-Rhizobium symbiosis is scanty. In the present study, N₂ fixation in eight Kersting's groundnut landraces were assessed in response to inoculation with two Bradyrhizobium strains (*B. japonicum* CB756 and *B. sp.* BR3267) at three locations (Savelugu, Tamale and Nyankpala) Ghana.

The results revealed marked differences in the shoot ¹⁵N of the test landraces due to variations in N₂ fixation. Symbiosis accounted for between 48 - 71% of the N demands of most landraces, and was evidenced by relatively lower values of both soil N uptake (21 - 49 kg N ha⁻¹) and ¹⁵N across the three locations. The amounts of N-fixed by the landraces ranged between 41 to 72 kg N ha⁻¹, and closely mirrored patterns of plant growth. Inoculation with either Bradyrhizobium strains resulted in lower shoot ¹⁵N values relative to the un-inoculated plants at Savelugu, translating into greater dependence on symbiosis by the inoculated plants. The landraces Heng Milk Mottled, Heng Red Mottled, Nakori and Sigiri fixed higher amounts of N in at least two of the locations. Grain yields of the landraces were generally low, and ranged from 164 - 959 kg.ha⁻¹. Studies on the symbiotic efficacy of indigenous rhizobia nodulating Kersting's groundnut could help enhance their role in soil fertility enhancement in traditional cropping systems of the tropics where most nutrient depleted soils occur.

Paper Number: 1039

The Role of Multi-Stakeholder Partnerships at the Maendeleo Innovation Platform in Eastern DRC: Gender and Bean Value Chain Development amidst Armed Conflict.

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In efforts to raise household incomes and fight poverty in developing countries, commercialization of traditional food crops (e.g beans) has often resulted in improved incomes and livelihoods for women farmers, who are culturally responsible for the production of these crops. Although experience shows that such improvements have often come with the cost of worsening household food nutrition, intra-household relationships, and increased labour input by the women, commercialization through value chain development amidst situations of armed conflict, presents additional challenges to both men and women farmers, which necessitate collaboration between mental health and development interventions. Maendeleo Innovation Platform (IP) was established by the Sub Saharan Africa Challenge Program (SSA CP) that was supported by the Forum for Agricultural Research in Africa (FARA) in 2008. Located in Rutshuru Territory, North Kivu Province of Eastern DRC, the IP was established to enable enhancement of household incomes through bean value chain development.

A wave of armed conflict that hit Eastern DRC in 2009 left hundreds of the residents of Rutshuru killed while others were displaced to settlement camps in the neighbouring countries. Since its establishment however, the IP still exists, although the entire territory remains insecure with sporadic incidents of banditry activities.

Given this situation, the purpose of this study is to enable relevant and informed interventions that will enhance the generation of socio-economic benefits to both men and women members of the Maendeleo IP. The overall objective is to conduct a gender analysis of the bean value chain at the IP.

The study thus aims to establish the roles played by women and men, what production resources and benefits they access and control, identify women’s gender needs, and establish levels of women’s empowerment imparted in the IP. The study further identifies gender disaggregated vulnerabilities, the capacities that the IP could build on, and the role that multi- stakeholder partnerships could play to support bean value chain development in the IP.

The study utilizes tools of gender analysis; the Harvard Analytical Framework with tools of the Activity, and Access and Control Profiles. The Moser framework is used to identify women’s practical and strategic gender needs, the Longwe framework to gauge women’s empowerment by the IP, and the Capabilities and Vulnerabilities Analysis (CVA). The tools were applied on a group of 28 women IP members, in a FGD that was held in Rubare centre, Kisigari groupement, in Rutshuru Territory, in December, 2015. Key informant interviews were also held.

The study shows that although women do most of the activities in the bean value chain, from production to marketing, and have access to production resources, they are not in control of the benefits arising thereof (Table 1). The women’s practical needs, which include availability of water for domestic use, firewood for cooking, ensuring household food security, and facilities for health care are being attended to by the numerous humanitarian and development agencies in the region. However, the women feel that they need to be recognized as major actors in the bean value chain, and to have control and enjoy the benefits of their labour.

Table 1. Access and Control Profile

Resources	Access		Control	
	Women	Men	Women	Men
• Land	+	+	+	+
• Cash				
• Material items e.g. bicycle, motorcycle, tools, chikudu		+		+
• Animals e.g. cows, goats, chicken, etc.	+	+		+
• House, store				
Credit	+	+	+	+
Training	+	+		+
Benefits				
• Revenue from beans	+	+		+

Source: Women’s focus group discussion in Rubare, Rutshuru territory, North Kivu Province.

Women have psychosocial needs arising from traumatic experiences of the war that need to be understood. These constrain production when they cannot attend to their fields because of the risk of sexual violation, as well as collective marketing since individuals have lost trust for each other. The study presents short stories of three sexually violated women, who are not able to join the IP because of stigma. They narrate their ordeal with sex violation, the effect that this has had on their lives, bean production and marketing, and give their views about the IP. Although the women IP members agreed that the IP enabled equal participation of members in decision making at the IP level, access to opportunities such as trainings, markets when available, seed, and general welfare, 4 out of 28 women rated the IP recognition of women’s issues as neutral, while 24 rate it as negative; the IP gives no reference to women’s issues. None of the women considered the IP as positively concerned with women’s issues (Table 2). This for them means that achieving equality with men does not necessarily address women’s issues.

Table 2. Gauging women’s empowerment by the IP

Level of Equality (Does the IP pursue equality between men and women in the following?)					Level of recognition of ‘women’s issues’(n=28)		
Welfare	Access	Conscientisation	Participation	Control	-ve	neutral	+ve
yes	yes	no	yes	no	24	4	0

Source: Women’s focus group discussion in Rubare, Rutshuru territory, North Kivu Province.

The capacities that the IP could build on include its ability to exist through times of war, and the existence of other organizations in the area that could be incorporated on the IP to offer relevant services that are currently not being offered. In many aspects, multi-stakeholder partnerships are important towards contributing to enhancement of legume value chains development. In this particular case such aspects include psychosocial and trauma counseling, which will not only motivate other stigmatized women producers to join the IP for social solace, but also revive confidence among members to strengthen collective marketing, and capacity building to operate credit and savings schemes on the IP. The organizations that offer these services could be identified and interested to join the IP as stakeholders. Agricultural Innovation Platforms established in situations of armed conflict should consider incorporating mental health agencies as stakeholders in value chain development processes.

Paper Number: 1040

Empowering Women for Food and Income Security: The Case of Pigeon Pea in Malawi.

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Legume-intensified maize systems have been identified as a potential “one stop” solution to the problem of food insecurity in Malawi. Previous research has failed to examine how gender relations and intra-household dynamics may influence decisions and potential food security gains at the farm level, or how gender may impact participation, performance, and benefits at later value chain stages. We examine how socio-cultural norms define roles and responsibilities for men and women involved in the value chain, how intra-household gender dynamics influence the allocation of resources and sharing of benefits from value chain participation within the household, and the implications for promoting the adoption of pigeon pea as a multipurpose legume in Malawi. We identify gender based constraints and opportunities along the chain and their implications for food security and poverty. Our findings suggest that women are concentrated at points with minimal resource requirements; have culturally circumscribed mobility; and reduced decision-making power. These gender based constraints must be taken into account by development efforts targeting food security and poverty within the context of changing climate and rapidly degrading soil quality due to cereal-based mono-cropping. We argue that empowering women economically is essential for harvesting the potential food security and poverty reduction benefits of legume expansion and commercialization. Improving women’s access to productive assets, their role in resource allocation, benefit sharing, and decision-making within the household is necessary to harvest the potential food security and poverty reduction benefits of legume expansion and commercialization.

Paper Number: 1041

Determinants of Smallholder Common Bean Market Participation and Extent of Participation in Rwanda By Gender.

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Determinants of smallholder common bean market participation and extent of participation in Rwanda by gender
Kelvin Kariuki¹, Patience Mshenga¹ and Eliud Birachi²

Abstract

Increased smallholder farmers’ market participation is an essential driver of the rural economy. It is important in improving the rural households’ livelihoods especially the FHHs who are normally resource constrained. A sample of 385 smallholder common bean farmers (67.5% MHHs and 32.5% FHHs) was used. Multistage sampling procedure together with proportionate to size sampling method were used to obtain the sample. Heckman two step model was used in the analysis. Market participation was represented by the choice to sell common beans or not. For market participation, a unit increase in years of schooling increased the probability of market participation by 3.22% among the FHHs. Among MHHs, a unit increase in the age of the household head decreased the probability of market participation by 1.43%. Extent of market participation was measured by the proportion of common bean sold against the total produced. For the extent of market participation and among the FHHs, a unit increase in the age of the household head decreased the extent of market participation by 0.8736, an acre increase in the land under beans increased the extent by 0.5397, access to credit increased the extent by 26.1982, group membership increased the extent by 34.4778 while a kilometer increase in distance to market decreased the extent by 15.9207. For the MHHs, a one acre increase in the land size increased the extent of market participation by 18.1396. To increase common bean market participation and its extent, women should be empowered in terms of education, access to land credit and markets.

Key words: Market participation, gender, female headed households, male headed households

Note: FHHs is Female headed households; MHHs is Male headed households

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APPENDICES

Table 1. Determinants of smallholder common bean market participation by gender

Variable	Overall				Male				Female			
	dy/dx	Std. Err.	z	P>z	dy/dx	Std. Err.	z	P>z	dy/dx	Std. Err.	z	P>z
HHAge	0.0036	0.0051	0.71	0.477	-0.0143**	0.0056	-2.54	0.011	0.0010	0.0024	0.43	0.668
HHMRTS	0.0382	0.0673	0.57	0.570	-0.0734	0.3041	-0.24	0.809	0.0128	0.0221	0.58	0.563
HHEduc	0.0235	0.0169	1.40	0.163	0.0158	0.0156	1.01	0.312	0.0322**	0.0157	2.06	0.040
BeanType	0.0396	0.1159	0.34	0.733	0.1192	0.0936	1.27	0.203	-0.2191*	0.1320	-1.66	0.097
Landbeans	-0.0025	0.0018	-1.36	0.175	-0.0010	0.0014	-0.74	0.459	-0.0017*	0.0010	-1.65	0.098
Labourused	-0.0228	0.0521	-0.44	0.661	-0.0317	0.0584	-0.54	0.588	-0.0169	0.0219	-0.77	0.440
Labselln	0.1853***	0.0497	3.73	0.000	0.2877***	0.0371	7.75	0.000	0.1301	0.0883	1.47	0.141
HHSize	-0.2172***	0.0654	-3.32	0.001	0.0154	0.0332	0.46	0.643	-0.0435	0.0303	-1.44	0.151
Landsz	0.0177*	0.0096	1.84	0.066	-0.0050	0.0227	-0.22	0.826	0.0042	0.0036	1.17	0.241
Landten	-0.0300	0.0503	-0.60	0.550		0.0415	0.29	0.769	-0.0100	0.0278	-0.36	0.718
Creditacc	0.2840	0.2696	1.05	0.292		0.2340	0.76	0.444	-0.0222	0.0903	-0.25	0.806
GroupMemb	-0.3419***	0.1199	-2.85	0.004		0.0926	-1.98	0.047	-0.0899	0.0714	-1.26	0.208
DistMkt	-0.1448*	0.0778	-1.86	0.063		0.0675	0.95	0.343	0.0043	0.0299	0.15	0.885

Note: ***: Significant at 1% significance level, **: Significant at 5% significance level, *: Significant at 10% significance level

Table 2. Determinants of the extent of common bean market participation by gender

Variable	Overall				Male				Female			
	Coef.	Std. Err.	z	P>z	dy/dx	Std. Err.	z	P>z	dy/dx	Std. Err.	z	P>z
HHAge	-0.8236**	0.3804	-2.16	0.030	-0.8658*	0.5131	-1.69	0.092	-0.8736**	0.3589	-2.43	0.015
HHMRTS	8.4622	11.3004	0.75	0.454	45.3523**	21.7193	2.09	0.037	4.3188	4.6914	0.92	0.357
HHEduc	1.4182	0.9574	1.48	0.139	0.9523	0.9560	1.00	0.319	3.9309*	2.1509	-1.83	0.068
BeanType	1.8310	5.3445	0.34	0.732	1.1252	5.2859	0.21	0.831	43.5884	27.0330	1.61	0.107
LandBeans	0.0886	0.0779	1.14	0.255	0.0516	0.0764	0.68	0.499	0.5397***	0.1586	3.40	0.001
Price	0.0435	0.0363	1.20	0.231	-0.0063	0.0430	-0.15	0.884	0.1404*	0.0847	-1.66	0.097
LabourUsed	-1.7161	3.0741	-0.56	0.577	-0.6550	3.1255	-0.21	0.834	0.7008	3.6948	0.19	0.850
LabourSelln	4.4677	3.6246	1.23	0.218	3.0322	5.2220	0.58	0.561	0.9862	2.1139	0.47	0.641
HHSize	3.4811	2.2456	1.55	0.121	2.8640	2.3473	1.22	0.222	6.8673*	3.7749	1.82	0.069
ExactLndSz	18.4649**	7.8408	2.35	0.019	18.1396**	8.1375	2.23	0.026	-0.1452	0.5726	-0.25	0.800
LndTen	-2.1828	2.1225	-1.03	0.304	-3.0223	2.1079	-1.43	0.152	4.0153	4.3103	0.93	0.352
CreditAcc	5.5732	9.8706	0.56	0.572	2.1326	9.8867	0.22	0.829	26.1982**	12.1985	-2.15	0.032
GrpMpshp	3.6454	5.4933	0.66	0.507	4.9176	5.3228	0.92	0.356	34.4778**	17.4786	1.97	0.049
DistMkt	-3.1276	3.9440	-0.79	0.428	-5.8590	4.1558	-1.41	0.159	15.9207**	7.0263	2.27	0.023

Note: ***: Significant at 1% significance level, **: Significant at 5% significance level, *: Significant at 10% significance level

Paper Number: 1042

Cultural Norms and Practices Influencing the Ethiopian Women Participation in Agricultural Training and Capacity Development.

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Introduction Studies have shown that successful participation in technology transfer projects has positive benefits in raising the self-confidence of rural women (Rathgeber, 2011). Moreover, access to technology and improvement of farming and production systems can have positive benefits not only from an economic perspective but also in helping to enhance the status of women. The technical knowledge of men and women in rural communities is usually based on the work that they do. According to Rathgeber (2011), women are particularly knowledgeable about seed diversity and plant breeding since they often have responsibility for collecting and storing seeds from one season to the next. In the Tropical Legumes II (TLII) project study areas, Rao et al. (2009) found out that men and women appear to make decisions regarding the sale of chickpea. Women are less familiar with modern markets and feel powerless to influence them. They are hampered by cultural norms, and the lack of access to information on new technology, prices, demand, etc. Unlike their husbands, they are rarely given training in modern small-business management. Studies on agricultural extension have highlighted a number of challenges in reaching rural women (Ragasa, 2014).

Moreover, under TLII project, various chickpea research and development activities were conducted, including participatory varietal selection, field days and demonstrations as well as training programs for farmers and extension staff (Ganga Rao et al., 2015). TLII focused on major chickpea producing areas in the Shewa region for the up-scaling of suitable chickpea varieties and marketing strategies (Asfaw et al., 2010). Notably, researchers working in the TLII under chickpea research and development program in Ethiopia highlight that there is very low participation of women in training events organized by the program compared to men. This is despite the program instituting a policy that every male farmer would be required to attend with the wife when coming for training. Even then, a training of about 70 participants would have only 5-6 women; and yet the scientists would see the women working on the chickpea fields [Ojiewo, 2015: Personal communication]. The gender research team designed a qualitative study to investigate the culture, the norms and practices that lead to low participation of Ethiopian Women farmers in field based extension and capacity building trainings.

This study involved conducting literature review using published and grey literature from studies elsewhere to understand the possible reasons for women's low participation in TLII chickpea training programs in Ethiopia. Insights from the reviews were then used to inform the design of vignette-based interviews, revolving around a young Ethiopian couple known as Gete and Getachaw, to guide the exploration of the cultural beliefs to expected behaviors and practices on farming practices, household decisions, negotiations for the man and woman in the house, interaction with extension agents and attendance to training. Social norms and their influences on women's and men's decisions are difficult topics for even well designed household surveys to explore effectively. Social norms of gender are in constant dialogue with women's agency and may determine women's capacity to act. Yet the scarcity of information on the role of social norms limits one's understanding of gender equality for possible policy action, and thus makes such information crucial (Chattier, 2014). Preliminary results from the field show that a man is recognized as the farmer in Ethiopia, even in official records. Ploughing, planting, harvesting and trading are the responsibilities of the men while women and children help in the weeding. Women are forbidden from broadcasting seeds and can only participate if row planting is practiced.

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This could be connected to religious thinking that sowing is the man's purpose in life, while a woman is the receiver not the one who gives seeds [Mahlet, personal communication].

The women's radius of movement is strictly short and strictly enforced by their husbands, whereby women account for their 'time out of home' strictly. The culture has engrained the enforcement of this rule into the definition of a 'good wife/good woman'. Women are expected to operate in 'private space' and hardly in the 'public space' unless accompanied by male relatives. The community proposes that having female extension workers would make it possible for the women farmers to spend time in training sessions. However, such trainings should be in the 'Kebele', and within a few hours on the appointed day. The women should be invited specifically by name, but if the announcements are general chiefs announcement, they don't feel obliged to attend, as their husbands won't approve their attendance. When meetings/trainings require spending a night away from home, then women don't even consider it to attend. This would call for very innovative approaches in 'training' and capacity building of women farmers in the Ethiopian farming systems, in chickpea production. Ragasa (2014) observed that in Ethiopia, extension agents were overwhelmingly male, and cultural taboos restricted their interaction with women. Like most developing countries, the number of women extension workers and national research women scientists is very low. But following on an example from Nigeria, it's possible to engage and work with local women groups, as Women in Agriculture Units, in dissemination of agricultural information (Anandajayasekaram et al., 2008), targeted to the women's role in production chain.

Paper Number: 1043

Influence of Group Factors on Women Empowerment in Collective Action: The Case of Bean Production in Central Uganda.

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The Women's Empowerment in Agriculture Index (WEAI) reveals weak leadership and influence in the community as the key domains that contribute most to women's disempowerment. These are majorly linked to women's lack of participation in groups and discomfort speaking in public. Although women play a central role in their contribution to the agriculture production process, their equitable participation in rural farmer groups remains minimal. The paper introduces a new discourse of participation by examining women leadership in collective bean production and marketing as a key area to improve women empowerment in Agriculture. Using data from sixty mixed farmer groups in Central Uganda, the study uses the tobit regression model to analyze group factors that drive the proportion of women in group leadership. Study finds women strong leadership skills lie tirelessly in being treasurers (70%), vice chairpersons (54%) and secretaries (38%) among others. Size of the group, number of economic activities dealt in, proportion of youth, record keeping, access to marketing information, and selling beans both on contract and freelance were the key group factors that influence the proportion of women in leadership positions at 1%, 5% and 10% significance levels. The findings would be useful in guiding development interventions that use group based approaches in grain legume production and marketing. Further research should focus on the influence of household factors of women in leadership because best designed development projects ought to take into recognition of these factors to fully empower rural woman.

Key words: Rural women, collective action, farmer groups, leadership roles

Paper Number: 1044

Gender Integration in the Innovation Platforms for the Scaling out of Innovations Cowpea in Ghana, Mali, Nigeria and Senegal.

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Cowpea, *Vigna unguiculata* (L) Walp, is the most important legume consumed in several countries in West Africa because of its richness in protein and its adaptation to difficult agro ecological. As part of its promotion in households, several innovative techniques are being broadcast in the study areas. The consideration of gender is very important in the functioning of innovation platforms, however, several constraints hamper the effective involvement of women and youth. They have no access to markets for inputs and products, and their participation is very low. The general objective of this study is to analyze the effective integration of gender in innovation platforms for better dissemination of new technologies of Cowpea. As hypotheses, women and young are less involved in the dissemination of technologies than men and also, their access to resources and income distribution in the innovation platforms. The study was carried out in Ghana, Mali, Senegal, Nigeria, using a structured questionnaire. The Harvard Analytical Framework, the Lorenz curve and the Gini coefficient were used to analyze the data. The results revealed that women and youth are not involved in all links of the cowpea value chains and have poor access to seeds, recommended insecticides, post-harvest equipment (bags PICS), credit and market products. Recipients from broadcasting activities in the platform are distributed inquality. Coaching and mentoring in innovation platform will permit to build the capacity of actors for the effective of gender integration.

Key words: gender, innovation platform, dissemination, cowpea.

Paper Number: 1045

Pigeonpea Research and Development Efforts in Eastern and Southern Africa: A Success Story.

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Pigeonpea is the crop of smallholder farmers in Eastern and Southern Africa (ESA) and about 6 million farm families depending on pigeonpea. It provides multiple benefits to cropping and farming systems through nutrient recycling, climatic resilience, sustainable intensification options, food and nutritional security, feed and fuel wood supply and income generation. ESA is the secondary centre of diversity and pigeonpea, being an often-cross pollinated crop, it is highly dynamic in genetic diversity and efforts are being made to capture this by germplasm collections in Kenya, Mozambique, Uganda and Tanzania. At present ICRAISAT holding about 1200 unique germplasm accessions collected from the ESA region. Pigeonpea has huge regional and international export potential and India alone imports about 500,000 t annually. ESA countries export about 200,000 t of grain/year worth of \$ 140 million. However, import demand from India alone is expected to increase further in coming years. Presently, pigeonpea area and production in ESA is about 1 million ha and 700,000 t, respectively with Tanzania, Malawi, Mozambique, Kenya and Uganda being the major pigeonpea producers. During the last fifteen years, area and production in ESA have increased dramatically by 109% and 146%, respectively. Tanzania and Malawi are showcasing path to success that guides other regional countries to follow. Pigeonpea improvement in ESA started in 1992 by mostly relying on native germplasm and about 32 high yielding varieties were released. This led to productivity gains in the region and in Malawi it has reached about 1327 kg/ha. The major breeding thrust was on high grain yield, inter-cropping compatibility, photo-period insensitivity, grain quality, resistance and/or tolerance to Fusarium wilt and Helicoverpa pod borer and resilience to climate change. Formal and informal seed systems are being strengthened during recent years and through various on-going projects about 3800 t of seed was disseminated. Maize-pigeonpea intercropping coupled with P fertilizer application increased yields of both pigeonpea and maize by at least 2 folds in ESA. Intercropping of pigeonpea with groundnut also showed promising results. Tremendous yield gains have been recorded with new varieties, integrated crop management, effective seed systems, export demand and policy support. However, a huge gap exists between realizable and actual yields with present management options. ICRISAT-India is effectively utilizing CMS based hybrid technology, genomic and genetic resources. Efforts are underway to use them in ESA breeding program to further elevate yield potentials. A strategy is being outlined to bridge this gap by using all the research and development options available including inclusive market oriented development.

Paper Number: 1046

G X E Effects in Food-Fodder Traits in 50 Cowpea Genotypes.

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Cowpea is an important legume grain crop cultivated extensively in Africa which accounts for around 95% of the global production. Apart from the grains that serve as dietary protein source in humans, cowpea haulms are an important & widely traded source of quality fodder for ruminants fetching additional income. Fifty genotypes of cowpea were evaluated over two consecutive years 2013-14 at five locations – Ibadan, Magaria, Malam-Madori, Minjibir and Shika in Nigeria to study the genotype by environment interaction on food and fodder attributes. Significant ($P < 0.05$) and wide variation in the grain yields (kg/ha) across varieties (532 to 1082), location (51 to 1070) and year (761 to 832) were observed. Cowpea haulm yields (kg/ha) across variety ranged from (1173 to 3368), locations (609 to 2348) and years (1569 to 2053) and differed significantly ($P < 0.05$). Grain and fodder yield were positively but weakly associated ($r = 0.26$) although it was not significant. Broad sense heritabilities of grain and fodder yield were moderate ($h^2 = 0.50$ and $h^2 0.29$). A two fold variation in the grain yield, roughly around three fold variation in the cowpea haulm yields and absence of negative correlations between grain and fodder yields across the genotypes are quite encouraging and plant breeders can select, breed and promote promising dual purpose varieties with high food and fodder yield.

Paper Number: 1047

Improved Legume Varieties and Seed Systems for Sub-Saharan Africa and South Asia - Lessons for Tropical Legumes III.

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Legumes represent the most affordable source of protein and micronutrients to the rural and urban poor and are especially important for hundreds of millions of women and children in Sub-Saharan Africa and South Asia. Improvements in their productivity are seen as a way of guaranteeing additional income while helping to diversify food production and income streams leading to risk mitigation associated with staple crop price fluctuations. Legumes contribute significantly towards reducing poverty, improving food security, nutrition, health, women empowerment and sustenance of the natural resource base. We present an important record of achievements across seven years of the Tropical Legumes project whose goal is to enhance productivity by at least 20%, achieve 30% area coverage with improved varieties and strengthen national capacity. 163 new varieties of groundnuts, beans, chickpea, cowpea, pigeonpea and soybean were released. 37 scientists were trained at MSc and PhD level. Seed production significantly increased by 221% between the phases I and II from 139,048 to 446,359 tons. The project adopted an inclusive approach for the poor, through farmers' participatory trials and promotion of innovative approaches, such as small seed packs, seed loans and decentralized production schemes. As a consequence, improved varieties have been adopted on 2 million ha and \$448 million has been generated from project funding and nearly \$976 million from project and investment partners. Economic analysis shows each dollar invested generated \$9 with direct project investment or \$20 with partnership's investment. This reveals that properly targeted interventions for the poor can make large impacts.

Paper Number: 1048

Advances in Chickpea Breeding in Eastern and Southern Africa: Current Status and Emerging Issues.

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Chickpea improvement efforts in Eastern and Southern Africa (ESA) started in mid-1970s, focusing mainly on yield improvement. Over the years, many challenges have evolved that require continuous research efforts, including biotic (wilt root-rot complex, Ascochyta blight, podborer) and abiotic (heat, drought and frost) constraints; farmer (herbicide tolerant, machine-harvestable, early maturing) and market (large seeded, fast cooking) preferences; integrated crop management packages that include inputs such as efficient and effective rhizobia inoculants as well as efficient seed and technology delivery systems. Since 2007, ICRISAT through the tropical legumes projects (TLI, TLII) worked closely with partners in ESA to address some of these challenges, contributing to release of 17 improved varieties targeting various agro-ecologies of Ethiopia (7), Kenya (6), Tanzania (4), and promotion of on-the-shelf varieties. Thanks to these efforts and others, the average productivity of chickpea in ESA over the past decade has nearly doubled from 653 kg/ha in 2003 to 1197 kg/ha in 2013, most of which is accounted for by productivity of Ethiopian chickpea which now stands at 1913 kg/ha, way above the world average of 968 kg/ha. Although these figures are impressive, there remains a huge untapped potential that can be achieved by bridging gaps between current and potential yields of more than 6000 kg/ha already being achieved in Israel. Innovative approaches to crop improvement, fast-tracking release of pipeline varieties and technology delivery under TLIII coupled with improved agronomy is expected to contribute significantly towards achieving this.

Paper Number: 1049

Tailoring Chickpea Varieties for Amenability to Machine Harvesting.

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Mechanized agriculture helps in bringing down cost of cultivation of crops. Traditional varieties of chickpea are bushy types hence unfit for machine harvesting. Efforts are being made by IIPR and ICRISAT to tailor chickpea varieties for their suitability to machine harvesting. Tall and erect non-lodging plant type not only ensures better solar light interception on the plant canopy enhancing photosynthesis but also helps in reducing the humidity inside the canopy which in turn minimizes the incidence of foliar diseases. IIPR and ICRISAT has developed large number of tall and erect elite breeding lines. 20 such lines along with check varieties (HC 5: tall and erect and DCP 92-3: high yielding) were evaluated in replicated trials under normal sown condition during winter 2013/14 for identification of suitable varieties for mechanical harvesting. Breeding lines viz., IPC 2006-11 (2155 kg/ha), IPC 2008-83 (1955 kg/ha), IPC2011-28 (1955 kg/ha), IPC 2011-85 (1953 kg/ha) and IPC 2011-113 (1933 kg/ha) out yielded the check varieties, HC 5 (1780 kg/ha) and DCP 92-3 (1645 kg/ha). Similarly, out of 24 tall and erect elite lines of kabuli chickpea evaluated, IPCK 2011-48, IPCK 2012-143, IPCK 2011-44 and IPCK 2011-3 performed well and out yielded the check varieties. These lines had more than 70 cm plant height and more than 600 branch angle besides lodging tolerance. It was also observed that lines with more than 800 angle had better solar light penetration in north Indian environment and are likely to have advantage due to reduction in humidity inside crop canopy.

Paper Number: 1050

A Pan-Legume Approach in Crop Simulation Modelling of Grain Legumes to Guide Breeding and Crop Management.

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Crop improvement, i.e. the science of combining genetics and agronomy to improve crop production, has become a difficult task since selection based on yield is coming to a limit and needs a better informed strategy to guide the choice of future breeding and management targets. In a context where funding to grain legumes is diminishing, crop improvement programs have little margin for error in identifying targets for improvement. In that context, crop simulation models are an increasingly powerful tool to guide decision making, both to assess potential gains but – more importantly – to assess the level of risk in investing in a given target. Here we describe a truly “pan-legume” crop model (SSM, Simple Simulation Modelling), developed around a similar architecture for several major grain legumes that share common growth and development dynamics. We then present the main achievements in its use to assist crop improvement in several legume species. For instance SSM was used to identify major crop improvement targets in chickpea, to study the effect of sowing density in groundnut, to explore the production potential of soybean in East and West Africa, or of lentils in East Africa, and to undertake yield gap analyses in chickpea. This is a non-exhaustive list of the demonstrations of the model's potential. We will also present how this work relates to the phenotyping and genetic analysis of several promising plant attributes, opening a new era of “gene-to-phenotype” modelling in support of modern crop improvement programs.

Paper Number: 1051

Evaluation of the Tepary Bean (*Phaseolus acutifolius*) Diversity Panel for Response to the NL 3 Strain of Bean Common Mosaic Necrosis Virus (BCMNV) and for Biological Nitrogen Fixation with Bradyrhizobium Strains.

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Aphid-transmitted Bean Common Mosaic Necrosis Virus (BCMNV) and Bean Common Mosaic Virus (BCMV) are potyviruses that are seed transmitted in tepary bean. Developing resistance to these viruses will be critical for expanding production in areas where they are endemic. Biological nitrogen fixation (BNF) also represents an important trait in tepary bean due to its effective nodulation with Bradyrhizobium strains.

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This study evaluated the response of 315 genotypes, from the CIAT and USDA collections, that compose the tepary diversity panel (TDP), for virus resistance and BNF related traits. Host reaction to NL3 strains was evaluated according to phenotypic symptoms known in common bean and by detecting the infection using the ELISA BCMV/BCMNV test. Tepary genotypes with venal necrosis, local necrotic lesions, and 5 accessions that had no reaction and no infection detected by ELISA were identified in the TDP. For BNF, superior nodulation according to measured parameters of nodules was identified with the Bradyrhizobium elkanii strain USDA 3254 in the group of cultivated accessions. The genetics of tepary response to NL3 BCMNV will be pursued and genotypes with a resistant response are being integrated as parents in the tepary breeding program as well as those with desirable nodulation characteristics.

Paper Number: 1052

Broad-Based Root-Knot Nematode Resistance in the Southeastern Africa Cowpea Gene Pool.

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Cowpea (*Vigna unguiculata* L. Walp) is a valuable source of proteins and important for food security in Africa. However, infection by root-knot nematodes (RKN), *Meloidogyne incognita* and *M. javanica* suppresses cowpea yield, and selection for virulence limits effectiveness of available Rk resistance genes. Fifty-three southeastern African genotypes (land-races and accessions), comprising cowpea gene pool 2, were screened for resistance to RKN in field, greenhouse and growth pouch tests. Response of cowpea genotypes to root-galling (GI) and egg-mass production (EM) showed that seven genotypes were consistently highly resistant (ANOVA, $P < 0.05$) to both RKN species. Virulence indexes, based on GI and EM on the resistant genotypes as a proportion of GI and EM on a susceptible control genotype, ranged from 6.24-30.8 % and 1.25-15.81 %, respectively, with *M. javanica* and 0-2.40 % and 0.20-1.85 %, respectively, with Rk-avirulent *M. incognita*. Virulence index, based on GI, of an Rk-virulent *M. incognita* on resistant cowpeas ranged from 11.07 to 39.48 %. GI and EM of the avirulent *M. incognita* on resistant cowpeas did not differ from that on control plants with gene Rk. The novel resistant genotypes had lower ($P < 0.05$) GI and EM induced by *M. javanica* than the control plants with gene Rk. Differences in GI and EM between the resistant genotypes and breeding lines carrying stacked Rk-genes were not significant ($P > 0.05$). The identified resistant genotypes are sources of effective RKN resistance for cowpea breeding; however, their uniqueness from known resistance sources is still to be determined.

Paper Number: 1053

Variability of *Pseudocercospora griseola* and Identification of New Sources of Resistance to Angular Leaf Spot Among Uganda Common Bean Landraces.

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Angular leaf spot (ALS), a fungal disease caused by *Pseudocercospora griseola* is an important constraint of common bean productivity in Africa, causing up to 80% yield losses. Efforts to breed for ALS resistance is challenged by the continuously evolving pathogen races that differ in different locations. Released varieties in Uganda are susceptible to ALS, moreover, the few exotic sources of resistance available are not well adapted to environmental conditions in Uganda. To overcome these challenges, a study was conducted to understand the pathogen variability and identify new sources of ALS resistance for deployment in ALS resistance breeding. Variability in 45 *P. griseola* pathotypes was elucidated using a set of 12 ALS differential cultivars, random amplified microsatellite markers and conserved sequences. The differentials and markers defined 12 pathotypes and 30 haplotypes respectively, which belonged to the Middle America and Andean gene pool groups with high variability. Among the 74 bean landraces screened using 1:6, 17:39, 21:39, and 61:63 *P. griseola* pathotypes, only U00279 showed consistent resistance to all pathotypes. U00297 resistance to pathotype 17:39 was conferred by a single dominant gene, while digenic epistatic gene interactions were responsible for resistance to other pathotypes. The dominant gene in U00297 was independent of resistance genes harbored by documented resistant sources AND277 and G5686. Our results revealed high variability in *P. griseola* and identified new source of ALS resistance. The divergent inheritance patterns of resistance to the different pathotypes indicated the importance of race specificity of the target organism in breeding for disease resistance. Key words: *Pseudocercospora griseola*, variability, resistance, inheritance, allelic

Paper Number: 1054

Genetic Diversity Assessment of Ugandan Cowpea Scab Fungus (*Sphaceloma* sp.) Isolates Using ISSR Markers.

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Scab (*Sphaceloma* sp) is a major disease of cowpea (*Vigna unguiculata*) in Uganda. It is wide spread and capable of causing yield losses up to 100% under severe infections. The disease affects all the above ground parts of the crop. Though the disease is wide occurring in the country, there is no information on the variability of the fungus in the country. ISSR markers were used to assess the genetic diversity of 28 isolates obtained from the major growing areas in the country. The isolates were found to have been grouped in to 4 clusters. The total differentiation among the isolates (PhiPT) was 0.034. The greatest differentiation was between populations from Amuria and Palisa (PhiPT = 0.686) and the smallest differentiation was between populations from Arua and Palisa (PhiPT = 0.309). There was no variation among the regions (Agro-ecological zones). The percentage of total molecular variance observed among the populations was 4% and within population was 96%. The study showed that there was a significant genetic diversity in the cowpea scab fungus in Uganda. It also suggested that there was no significant influence of geographic distance on genetic variability.

Paper Number: 1055

Pathogenicity of *Sclerotium Rolfsii* Sacc. and Identification of Resistance Sources in Common Beans.

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Common bean (*Phaseolus vulgaris* L.) root rots remain one of the biggest biotic constraints to bean production, causing losses estimated at 221,000 metric tons per year in sub-Saharan Africa. Until recently, root rots in Ugandan bean agro-ecologies were mostly caused by *Pythium* and *Fusarium* spp., especially in high altitude areas. But now severe root rots occur in low and medium altitude bean agro-ecologies characterized by dry and warm conditions. These root rots have been identified as *Sclerotium* rots caused by *Sclerotium rolfsii* Sacc. Pathogenicity of 78 representative *S. rolfsii* isolates on five lines (MLB-49-89A, NABE15, RWR719, ALB5 and CAL96) with varying levels of *Pythium* and *Fusarium* root rot resistance showed severe disease following infection by the pathogen. Pre-germination infection of seeds was very high, with four isolates inhibiting germination 100% in lines MLB-49-89A, NABE15, RWR719 and CAL96. For seeds that germinated, root rot severities ranged between 0-100 percent. Due to the susceptibility of known root rot resistance sources, germplasm evaluation to identify sources of resistance to *S. rolfsii* is ongoing. We have evaluated lines from the Andean Diversity Panel (ADP), 132 ALBs (SER 16 x *Phaseolus coccineus*), 20 lines from a *Pythium* root rot nursery developed in Kenya and several lines from the Ugandan local germplasm collection. However, we still have not identified a line that is conclusively resistant to *S. rolfsii*. Given the importance of *Sclerotium* root rot disease, there is urgent need to validate management practices for *Sclerotium* root rots; and to identify resistance sources for use in variety improvement. Keywords: Dry beans, Root rots, Resistance sources, Root rot management

Paper Number: 1056

Effect of Methanol Extracts of *Leonotis Nepetifolia* and *Ocimum Gratissimum* on the Incidence and Severity of *Ascochyta* Blight of French Bean.

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French bean (*Phaseolus vulgaris* L.) is an important export vegetable crop that faces serious production challenge due to *Ascochyta* blight (*Phoma exigua*) infestation. The conventional use of synthetic fungicides has resulted in environmental degradation and rejection of the produce in the international markets due to high MRLs. The potential of crude plant extracts as antimicrobial agents has been demonstrated both in animal and plant health. However, their antifungal activities have not been tested under field conditions. The objective of this study was to determine the efficacy of *Leonotis nepetifolia* L. and *Ocimum gratissimum* L. plant extracts on the incidence and severity of *Ascochyta* blight on French beans in vivo. *Ocimum gratissimum* at a rate of 5.0 mg ml⁻¹ and LN at 20.0 mg ml⁻¹ resulted in a reduction of disease incidence by 41.1 and 44.5% respectively. Extracts of *O. gratissimum* and *L. nepetifolia* at 10.0 and 20.0 mg ml⁻¹ reduced *Ascochyta* blight severity to 13.45 and 13.14%, respectively. The results demonstrate the antifungal activity of *L. nepetifolia* and *Ocimum gratissimum*, and the potential to be used as natural alternatives to synthetic fungicides in managing *Ascochyta* blight in French bean.

Moreover, these findings provide an insight to the potential of plant extracts to be used for dressing bean seeds to control soil-borne fungal diseases.

Keywords: Antifungal activity, Ascochyta blight, Leonotis nepetifolia, Ocimum gratissimum, Phoma exigua, in vivo

Paper Number: 1057 (Poster Number: 1)

Evaluation of Morpho-Physiological Traits Linked to Drought Tolerance in Chickpea (*Cicer arietinum* L.) Lines.

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EVALUATION OF MORPHO-PHYSIOLOGICAL TRAITS LINKED TO DROUGHT TOLERANCE IN CHICKPEA (*Cicer arietinum* L.) LINES Muriuki R. W, Egerton University, Crops, Horticulture and Soil Science Dept P.O. Box 536 Njoro, Kenya Corresponding Email: ruthwangari.muriuki@gmail.com The presenting author is a student Egerton University, Crops and Soil Science Dept P.O. Box 536 Njoro, Kenya Mobile: +254725582692 Co authors: Kimurto P. K, Vadez V2, Towett B.K1, Kosgei A.J3, Nganga J1 and Lilian J1 1Egerton University, Crops and Soil Science Dept P.O. Box 536 Njoro, Kenya 2 International Crops Research Institute for Semi-Arid Tropics (ICRISAT) Mobile: +254725309162 Category: Abiotic stress Preference: Oral session Drought is stress is the single most important constraint to yield in chickpea accounting for 40-50% yield reduction globally and also in Kenya. Roots are among the first defence towards drought with other morpho-physiological and biochemical mechanisms employed by plants. More the roots enhance high capacity to absorb soil water. This study determined the root characteristics associated with water stress tolerance in selected chickpea lines based on contrasting water stress tolerance responses among parental genotypes in a rainout shelter at Egerton University, Njoro and their grain yield performance under water stress field conditions in arid and semi arid lands (ASALs) of Kenya. The chickpea genotypes were evaluated under rain shelter in Polyvinyl chloride (PVC) cylinders measuring 120 cm long and 20 cm diameter in a Completely Randomized Block Design (RCBD). The field experiment was conducted at two site under rainfed at Chemeron Dry Land and eco-tourism Research station and Kenya under irrigated conditions at Agricultural and Livestock Research Institute (KALRO-Marigat) for two seasons (2013/2014). The trial was laid in RCBD with 3 replicates at a spacing of 30cm x 10cm (25 plants m⁻²). The results showed that there was large variation in root biomass (0.16 -0.77gms/plant). Genotype ICCV 92944 had the greatest root biomass followed by ICC 283 and ICCV 97306 while genotype ICC 4958 had the highest root length density (RLD) and longest roots, followed by ICC 283 and ICC 3325. Genotypes ICCV 92944, ICCV 00108 and ICC 4958 had highest shoot biomass. These traits were correlated with drought. Field results showed that genotypes ICCV 92318 and ICC 1882 had the largest seeds in Marigat (irrigated) and Chemeron (rainfed) sites respectively. Grain yield ranged from 112-867 kg ha⁻¹ in both conditions. On average irrigated conditions had a higher mean grain yield as compared to the irrigated condition. Genotype Cavir was the largest genotype while ICC 283 had the highest seedling survival rate and thus total biomass and seed weight. These results indicate that seedling survival up to maturity is important to ensure a good harvest which in turn will ensure higher yield. The findings of this study showed that drought tolerance traits such as root biomass, RLD, shoot biomass and root length of genotypes could be used for indirect selection for drought tolerance in ASALs. Genotypes ICCV 92944 and ICC 4958 could be used for improving susceptible genotypes through root in retrogression Key words: Genotypes, drought stress, Root length density (RLD) and root biomass

Paper Number: 1058 (Poster Number: 2)

Breeding Climate Resilient Chickpea Varieties.

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Chickpea is expected to have greater incidences of drought and heat stresses due to climate change. These abiotic stresses are already causing heavy yield losses in chickpea as the crop is largely grown rainfed on residual soil moisture and its area has considerably increased in the semi-arid tropics and also in the late sown conditions. Improved varieties with tolerance to terminal drought and heat stresses are needed for enhancing resilience of chickpea to the impacts of climate change and opportunities for expansion of its cultivation to new niches. Excellent progress has been made in development of early maturing varieties that can escape terminal drought and heat stresses. Adoption of early maturing varieties has shown high impacts on enhancement of chickpea area and productivity in short-season environments, e.g. Myanmar and southern India. Efforts have been made to develop varieties that can avoid/tolerate terminal drought (greater extraction of water from the soil, enhanced water use efficiency) and heat stresses. Breeding lines with improved drought tolerance have been developed through marker-assisted introgression of a genomic region that controls root traits and several other drought tolerance related traits.

Large genetic variations have been identified in chickpea for heat tolerance by screening of germplasm/breeding lines under heat stress conditions in the field. Several varieties are now available which can tolerate high temperatures at the reproductive stage. Efforts are being made to develop varieties with combined tolerance to drought and heat stresses for further enhancing their resilience to climate change.

Paper Number: 1059 (Poster Number: 3)

Adaptation of Pigeonpea (*Cajanus cajan*) to Southern Africa and Its Implications.

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Pigeonpea is an important grain legume which originated from the Indian sub-continent. It is useful for human consumption and contributes to soil fertility through biological nitrogen fixation. It is also tolerant to drought and therefore suitable for production in areas prone to drought. In Africa, it is cultivated largely in east Africa by smallholder growers who rely frequently on traditional unimproved long duration (LD) types (> 6 months to mature). However, the LD pigeonpea types are sensitive to photoperiod when cultivated in high latitude areas (> 10° away from the Equator) thus leading to poor adoption by growers in southern Africa. Therefore, the objectives of this study were to select for medium duration (MD) types of pigeonpea and evaluate their agronomic performance in new (or non-traditional) potential production areas in southern Africa such as the Limpopo River Basin (LRB). The results of the study showed that the new MD types flowered and matured within 150 d at two representative locations in the LRB. The best cultivar obtained 1.80 t/ha and 1.34 t/ha on average over two consecutive seasons at Thohoyandou (21° S) and Rustenburg (25° S). The results were consistent with observations reported in similar studies that were conducted elsewhere in Africa and suggested that the new MD pigeonpea types are adapted to high latitude areas in southern Africa. These new types provide options for legume growers and thus contribute to household food security in the region.

Paper Number: 1060 (Poster Number: 4)

Physiological and Agronomic Responses of Selected of Cowpea (*Vigna unguiculata* (L.) Walp) Landraces to Moisture Stress.

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Frequent droughts in Malawi point to the need for developing new crop varieties which could perform better under low moisture. Five cowpea landraces (479, 601, 645, 2226, 3254 and 2232) were evaluated in a glasshouse and field in order to identify genotypes with desirable physiological and agronomic attributes under moisture stress conditions. Significant differences ($P < 0.0001$) were observed among genotypes for relative water content, stomata conductance, transpiration rate, net photosynthesis, grain yield and seed size. Genotype 3254 maintained high relative water content and photosynthetic capacity during the period of stress in glasshouse; and gave high yield and medium seed size under low rainfall and high temperature conditions in the field. In contrast, 2232 reduced relative water content and net photosynthesis under stress conditions and reduced yields and seed size under low rainfall and high temperature field conditions. The other four genotypes showed early reduction in stomata conductance, transpiration rate and net photosynthesis as a water conservation mechanism and also showed intermediate yield performance in areas with low rainfall and high temperature. Both agronomic and physiological responses demonstrate that 3254 possesses drought tolerance due to high photosynthetic capacity and high yield under moisture stress conditions; 479, 601, 645 and 2226 possess drought avoidance due to reduction in the physiological traits and moderate yield performance; and 2232 is drought susceptible due to low photosynthetic capacity, low yields and reduced seed size under moisture stress conditions. Therefore, genetic studies should be further pursued for the identification of good parental lines for drought tolerance breeding.

Paper Number: 1061 (Poster Number: 5)

Discovery of Quantitative Trait Loci Underlying Drought Tolerance in the (SEQ1027 X BRB191) F2 RIL Population of Common Bean (*Phaseolus Vulgaris* L).

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Drought is a major constraint affecting over 40% of dry bean production in Sub Saharan Africa causing crop failure, hunger and poverty. Several studies over the past two decades have reported a number of physiological and phenological traits associated with drought tolerance in the common bean. However, the genetic mechanism associated with these traits is still not fully understood especially in the Andean gene pool.

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The aim of this study was to identify phenotypic traits and Quantitative Trait loci (QTL) associated with drought tolerance in 132 recombinant inbred lines (RILs) from an Andean cross of a drought tolerant line SEQ1027 and drought susceptible cultivar, BRB191. The study evaluated twenty one traits for three seasons under both irrigated and non-irrigated conditions in the field and screen house at CIAT, Uganda. Results showed that harvest indices, seed weight, pods per plant, and pod wall biomass proportion were stable regardless of water treatment while yield, stem bean reduction, pod partitioning index and canopy biomass readings at mid-pod filling and harvest were significantly reduced by drought ($P < 0.001$). SCMR (chlorophyll) readings were weakly correlated with canopy biomass readings ($r=0.15$, $P < 0.05$). Results from this study implied existence of non-linear relationships between phenotypic traits hence further research to fully understand the mechanistic behavior of these traits is needed. This study will identify QTLs which will greatly contribute to marker assisted selection (MAS) and introgression of desirable agronomic traits in Andean beans and also complement previous research that was restricted to Mesoamerican and intergene pool crosses.

Paper Number: 1062 (Poster Number: 6)

Breeding Next Generation Cowpea Varieties for Adaptation to Changing Climates and Multiple Cropping Systems.

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Cowpea is an important crop in over 80 countries covering the tropics and sub-tropics. Joint efforts by national and international programs from 1960 onwards have led to the development of improved cowpea varieties combining resistance to diseases, insects and Striga resulting in increased cowpea production from 0.87 million tons in 1961 to over 7.0 million tons in 2013. However, in the wake of rising temperatures, erratic rainfall, declining water table, increasing drought incidence, declining soil fertility and pressure to use less fertilizers and pesticides, the next generation cowpea varieties must be stress resilient to address these challenges. Using best cowpea varieties from IITA and Texas as parents, a number of new populations and improved cowpea varieties have been developed which combine high levels of tolerance to heat, drought, low soil-P and resistance to major diseases and pests. Some of these yield up to 2.5t/ha grain and fodder within 60-70 days with 27-30% protein in grains and 15-18% protein in fodder and require less rainfall, less pesticides and fertilizers. Some of these also fit well as a niche crop in various cropping systems such as 'wheat-cowpea-rice' system in northern India, 'rice-cowpea-rice' system in Central and Southern India, 'maize-double cowpea' strip cropping in Nigeria, 'maize-cowpea' rotation in South Africa, 'wheat-cowpea' and 'maize-cowpea' double cropping in mid-western and southern USA and 'soybean-cowpea' double cropping in the Brazilian savannas. Efforts are underway to combine conventional and molecular approaches to develop new cowpeas to make it a major food legume in the 21st century.

Paper Number: 1063 (Poster Number: 7)

Impact of Water Stress on Stomatal Conductance, Carbon Isotope Discrimination and Biological Nitrogen Fixation in Four Cowpea Genotypes.

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Cowpea (*Vigna unguiculata*) plays an important role in improving soil fertility in resource poor farms most of which are located in arid and semi-arid areas which are constantly threatened by droughts and erratic rains. Despite its importance, cowpea improvement is hindered by limited knowledge of the crop's physiological responses to limited water supply. A field study was carried out to investigate the effect of water stress on: stomatal conductance (gs), biological nitrogen fixation (BNF), and carbon isotope composition ($\delta^{13}C$). Four cowpea lines (IT00K-529-1, IT99K-1122, TVu14632 and TVu4607) were grown under four moisture levels [severe stress (SS), moderate stress (MS), moderately well watered (MW) and well watered (WW)]. Genotypes differed in the stomatal conductance measured at 47 days after planting (DAP) under severe water stress conditions. In addition, a strong positive relationship was observed between early season gs and biomass accumulation (0.58^{**}) under the same moisture level (SS). Crop biomass accumulation was however not correlated to gs measured at 54, 70 and 77 DAP. This indicates a stronger influence of early season gs on cowpea biomass accumulation. A positive relationship between $\delta^{13}C$ and gs under SS was also observed, an indication of genotypic differences in CO₂ fixation under water stress. BNF varied among the cowpea genotypes as well as moisture levels, with amount of nitrogen fixed by the genotypes ranging from 22.5 kgN/ha-1 for TVu14632 to 44.1 kgN/ha-1 for TVu4607. The results of this study show that early season gs could be useful for breeding towards improved drought tolerance in cowpea.

Paper Number: 1064 (Poster Number: 8)

Genome-Wide Association Studies of Morphological and Agronomical Traits in Cultivated Tepary Beans (*Phaseolus acutifolius*).

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Tepary bean (*Phaseolus acutifolius* A. Gray) is adapted to high temperature arid agroecological zones. In light of the ongoing and rapid changes in the world climate, the evaluation and development of alternate grain legume species that have similar nutritional and culinary characteristics as common bean, such as tepary bean, is needed to enhance food security in existing marginal environments and in preparation for a hotter, drier future. One hundred and fifty two cultivated accessions from the Tepary Diversity Panel (TDP), composed of a total of 315 domesticated and wild *P. acutifolius* accessions available from the USDA and CIAT collections, were evaluated in Puerto Rico, Colorado, and Arizona for yield, agronomic, leaf, and seed traits. Genome-wide association studies (GWAS) were conducted on these phenotypes and 18,500 SNPs that resulted from ApeKI genotyping-by-sequencing and alignment to the *P. vulgaris* reference genome. These studies resulted in the identification of quantitative trait loci for morphological and agronomic traits. Tepary bean accessions with superior yield performance under abiotic stress and with improved disease resistance, seed quality and agronomic performance are being incorporated into the tepary breeding program at ARS-TARS, while specific traits are being considered for the development, validation, and application of marker assisted selection. Superior accessions and breeding lines are being tested further for potential production in East Africa and Latin America in a freely available Tepary Adaptation Trial (TAT).

Paper Number: 1065 (Poster Number: 9)

Marker-Assisted Backcrossing to Improve Cowpea for Drought Tolerance.

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Cowpea (*Vigna unguiculata* L. Walp.) is one of the cheapest sources of protein for rural people in Burkina Faso. It's the first crop harvested during the cropping season before staple cereals crops and therefore, it is referred to as a "hungry-season crop" playing also a role cash-crop. However, its production is constrained by both biotic and abiotic constraints such as drought, and Striga. Therefore, there was a need to breed for resistance to such traits exploiting the modern breeding technology such as marker-assisted backcross (MABC) approaches. Thus, 184 SNP markers were selected using SNP-Selector (flanking markers at 2cM from the QTLs and Background markers at every 5 cM distance). QTLs for yield under drought stay green QTLs and Striga resistance were introgressed using two drought tolerant lines into Moussa local, a farmer preferred landrace using the Backcross selector tool from UCR cowpea team. Six BC3F2s from the two populations were obtained and evaluated in RCBD with the three parents and one drought-tolerant check (Gorom local) for yield performance. The BC3F2s lines evaluated for preliminary yield under stress and non-stress conditions showed three promising MABC selected lines that yielded better than the drought-tolerant check and the two parents.

Paper Number: 1066 (Poster Number: 10)

Photosynthetic Traits Associated with Drought Tolerance in Common Bean Seedling.

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PHOTOSYNTHETIC TRAITS ASSOCIATED WITH DROUGHT TOLERANCE IN COMMON BEAN SEEDLING
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Drought is an abiotic stress that limits growth and development of common bean (*Phaseolus vulgaris* L.). Shoot traits play an important role in regulating physiological and biochemical processes such as photosynthesis, evapotranspiration, and accumulation of metabolites in response to drought stress. The objective of this study was to identify photosynthetic traits associated drought stress in common bean seedling. The experiment consisted of 230 common bean genotypes, assembled from the Andean diversity panel (ADP). The panel was evaluated in the greenhouse under drought and non-drought conditions with four replications. Drought stress was applied by withholding watering 24 days after planting to genotypes grown in shallow soil profile. This limited root growth and consequently minimized root effects for unbiased assessment of shoot traits under drought stress. Photosynthetic traits such as photosystem II efficiency (PSII), non-photochemical quenching (NPQ), chlorophyll content (SPAD), and other shoot traits including wilting, stem greenness, and leaf senescence were measured every two days. These measurements were then repeated after recovery from drought condition.

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Substantial genetic variability was observed among the genotypes for photosynthetic traits as drought stress condition progressed. We will discuss the potential of photosynthetic traits associated with drought tolerance at seedling stage and their potential usefulness for high throughput screening for drought tolerance in common bean.

Paper Number: 1067 (Poster Number: 11)

Evaluation of Common Bean Lines for Adaptation to High Temperatures in Honduras.

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As in other regions worldwide, common bean (*Phaseolus vulgaris* L.) production in Central America and the Caribbean (CA/C) region is threatened by effects of climate change including increasing temperatures and drought due to variable rainfall patterns. One of the main alternatives for increasing adaptation of common beans to high temperatures is through breeding and selection. Therefore, the objective of this research was to identify promising bean lines tolerant to high temperatures with potential for commercial production and for use as breeding parents for genetic improvement of adaptation to heat stress. A wide array of cultivars and promising breeding lines were tested under high temperatures conditions by a consortium of bean researchers in CA/C, Africa and the U.S. to identify potential cultivars and breeding parents. The Bean Research Program of Zamorano University evaluated more than 250 bean lines in a series of trials conducted during three planting seasons in 2015 under high temperatures conditions in Nacaome, Honduras. Maximum average temperatures during the summer (Feb-Apr), "primera" (May-Aug) and "postrera" (Oct-Dec) seasons were 37.9, 39.1 and 38.2°C and the minimum average temperatures were 23.0, 24.2 and 24.1°C, respectively. Shoot biomass and pod dry weights (DW), pods partition index at the pod-filling stage of development, pod and seed DW, harvest index, seed yield and 100 seeds weight at harvest maturity were measured in most trials. Pod formation was monitored from flowering to physiological maturity. More than 30% of 120 lines did not reach physiological maturity due to flower and young pod abortion in the BASE (Bean Adaptation Stress Evaluation) trial conducted in the summer season under adequate irrigation. Selected genotypes from the BASE trial and from four regional trials which are distributed annually through the CA/C Bean Research Network, were evaluated during the "primera" season. Promising heat tolerant genotypes selected from all previous trials were evaluated during the "postrera" season. A small group of heat tolerant lines were identified from the trials conducted in 2015. Some lines also have desirable agronomic and commercial traits, including virus resistance and excellent quality in the small red and black market classes. The heat tolerant line SJC 730-79, was recently released as a cultivar in El Salvador. Some other promising lines identified as heat tolerant in this study are being tested under farmer conditions for potential release as cultivars in Honduras and other countries of the CA/C region.

Paper Number: 1068 (Poster Number: 12)

Association Mapping for Drought Tolerance in Intergenepool Populations in Common Bean (*Phaseolus vulgaris*).

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Drought is a major cause of low productivity in common bean and most agronomic methods to alleviate drought are cost prohibitive for low-income smallholder farmers. Breeding for drought tolerance was found to be the most economical and sustainable option to increase yield stability in common bean production in drought conditions. However the conventional breeding could spend so much time and resources, therefore, a good option to decrease the time and resources is the molecular assisted selection. The main goal of this study was find associations between DNA region and traits that confer drought tolerance. To accomplish this goal we used an intergenepool population, which was formed by simple crosses between five drought tolerant lines of Mesoamerican origin and five lines susceptible to drought of Andean origin with high importance in Zimbabwe Africa, using a crossing design North Carolina II. We select 200 hundred individual including the parents in representation of all crosses, which were evaluated in 4 different trials, two of them in rainfed like controls and two in drought. We used genotyping by sequencing to obtain the SNP molecular markers. After association analysis we found 37 markers associated to flowering days, 23 to maturity days, 20 to number of pod per plant, 39 to yield, 33 to one hundred seed weight, 24 to harvest index, 36 to depression of canopy temperature and finally 9 to pod harvest index. We hope use the information obtaining in this study in a new programs of molecular assisted selection for drought tolerance in Common bean inside the International Center for Tropical Agriculture.

Paper Number: 1069 (Poster Number: 13)

Preliminary Screening of USDA Lentil Core Collection for Heat Tolerance.

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In many important agricultural areas, drought stress, coupled with heat stress, has increased in recent years due to global climate change. Lentil (*Lens culinaris* ssp. *culinaris*) is one of the most important cool season legume crop facing terminal heat stress in South Asia, North America, North Africa and Australia. Increase in air temperature (>32°C) during flowering, decreases the yield of spring-sown lentils as a result of nonviable pollen, reduced pod set, decreased seed filling and reduced recovery rate of lentil plants. Therefore, heat tolerant lentil varieties are the burning demand for the lentil growers across the world. The USDA core collection (which represents the diverse collection of accessions across the world) and the ICARDA lentil reference population were screened for heat tolerance at two diverse locations in southeastern Washington during summer 2015. The 396 accessions were planted in a randomized complete block design with three replications. Days to flowering, plant height, no. of pods per five plants, flowering to 50% pod set interval, seed weight, total biomass and seed yield data were collected. Spectral reflectance facilities allowed high throughput phenotyping. Normalized difference vegetation index (NDVI), photochemical reflectance index (PRI) and water band index (WBI) were estimated. Significant correlations were found among NDVI, biomass and yield. Performance of those varieties at Central ferry and west Whitlow are determined by broad sense heritability and additive main effects and multiplicative interaction (AMMI) analysis. Approximately 30 accessions were selected based on direct selection for yield and indirect selection for secondary traits. Phenotyping of those accessions will be used for an association mapping study.

Paper Number: 1070 (Poster Number: 14)

Terminal Drought Tolerance in the Andean Diversity Panel.

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Terminal drought is a major constraint for dryland common bean (*Phaseolus vulgaris*) production. Our objective was to identify and characterize drought tolerant and susceptible lines from the Andean diversity panel (ADP) under non-stressed (NS) and drought-stressed (DS) environments at Othello, Washington from 2012 to 2015. Terminal drought stress was simulated by ceasing irrigation at or before flowering compared to non-stress which was watered as needed. Phenology, root (shovelomics), yield and yield component traits were measured in replicated trials. Drought intensity index (DII) averaged 40% for 2012 and 2014, indicating moderate drought conditions. No drought was observed in 2013 due to a high water table in the DS treatment. The 2015 data is awaiting analysis. Yield under DS ranged from 490 to 4790 kg/ha and 460 to 3500.00 kg/ha in 2012 and 2014, respectively. Seed size (g 100 seeds⁻¹) was reduced by 2.8 and 4.8 g under DS in 2012 and 2014, respectively. OPS-RS1 (ADP-114) 'sugar' cultivar from South Africa and Kablanketi (ADP-80) landrace from Tanzania exhibited superior performance across years as indicated by respective geometric means (GM) of 4520 and 4490 kg/ha in 2012, and 3140 and 3240 kg/ha in 2014. Several traits under DS were significantly ($P < 0.01$) correlated with traits under NS implying that selection under drought conditions may lead to the identification of genotypes suitable for optimal conditions as well. Identified ADP lines exhibiting tolerance to terminal drought have been used in crosses to generate populations for breeding improved drought resistance in African dry bean germplasm.

Paper Number: 1071 (Poster Number: 15)

Tithonia Diversifolia, Potential Alternative Solution to the Lack and High Cost of Fertilizers for Increasing Common Bean Productivity: Case of Moso Region of Burundi.

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Insufficient organic manure, unavailability and high cost of inorganic fertilizers, compared to the means of smallholder farmers, have led to declining bean productivity. After promising results from on station experiments, demonstration plots with farmers were conducted to assess the effect of *Tithonia diversifolia* on common bean yield. The on farm demonstrations were conducted in Moso region of eastern agro-ecological zone of Burundi during the cropping seasons 2010B, 2012B, 2013A and 2013B. The evaluation consisted to apply the following fertilization regime : (i) Fresh biomass of *Tithonia diversifolia* (22.2 t/ha) + Di-Amonium Phosphate (DAP) (100 kg/ha), (ii) DAP (100 kg/ha), (iii) Fresh biomass of *Tithonia diversifolia* (22.2 t/ha), and (iv) the control (no fertilizer application). Fresh biomass of *Tithonia diversifolia* was applied in furrows one to two weeks before sowing date while DAP was applied at the sowing time. The results showed that *Tithonia diversifolia* applied either alone or combined with DAP, produced a significant (p

Paper Number: 1072 (Poster Number: 16)

Enhanced Drought Tolerance in Transgenic VuP5CS Cowpeas.

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Cowpeas (*Vigna unguiculata*) are widely grown in Kenya with 90% of the national production being from the drier Eastern province. The current climate change has led to uncertainties in planting time resulting in poor yield. Proline has been reported to increase in plants during water stress, with P5CS being the rate limiting catalyst in proline biosynthesis. This study sought to analyse the drought and salt tolerance potential of Kenyan cowpeas transformed with the *Vigna unguiculata* (Vu)P5CS gene. Seeds harvested from transformed and non-transformed plants were irrigated with 300mM NaCl or had water withdrawn for 2 weeks, 4 weeks after sowing. Proline concentration was measured every 3 days for 2 weeks, after which the relative water content (RWC), leaf scorch and root lengths were analysed. Proline levels were higher in the VuP5CS transformed plants than the non transformed plants under both water and salt stress. The transformed plants also had significantly higher RWC with longer roots than the non transformed plants subjected to water stress. There was however no significant difference in both RWC and root length in the transformed and non transformed plants after 2 weeks of salt stress, with slight chlorosis observed in 33% of both transformed and non transformed plants. The VuP5CS transformed cowpeas have potential for enhanced tolerance to water stress, but there is need to further evaluate yield in the VuP5CS transformed versus non transformed plants under water stress. The VuP5CS gene can also be used to transform other grain legumes for enhanced drought tolerance.

Paper Number: 1073 (Poster Number: 17)

Bambara Groundnut - an Exemplar Drought Tolerant Underutilised Legume.

Tafadzwanashe Mabhaudhi and Albert Thembinkosi Modi, University of KwaZulu-Natal*

Bambara groundnut (*Vigna subterranea* L. Verdc) is an underutilised species with potential to contribute to food and nutrition security. However, the promotion of exotic groundnuts (*Arachis hypogaea* L.) has resulted in *Vigna subterranea* being a neglected underutilised species (NUS), despite it holding much potential for planting in arid, semi-arid and other marginal production conditions. Decades of 'neglect' by researchers in favour of major crops have led to limited robust and comparable empirical information describing NUS. It was hypothesised that local bambara groundnut landraces may have acquired tolerance to drought stress through years of natural and farmer selection under often harsh conditions. A secondary hypothesis was that bambara groundnut was suitable for alternative cropping systems such as intercropping and that it could serve as a dual purpose crop for feeding humans and livestock. To test these hypotheses, conventional (controlled and field trials) and modelling approaches were adopted in experiments spanning a period from 2008/09 to 2014/15 seasons. These included experiments evaluating agronomy, drought tolerance mechanisms, alternative cropping systems and uses as well as modelling yield responses of bambara groundnut landraces. Conventional experiments were based on replicated (x3) randomised complete block designs and data were used to parameterise and test the FAO's AquaCrop model. Seed quality, linked to emergence, was shown to be poor in the studied landraces; this resulted in times to emergence of, on average, 35 days after planting. Bambara groundnut landraces were shown to be drought tolerant. This was attributed to a combination of avoidance and escape mechanisms. Drought avoidance in bambara groundnut was associated with reduced canopy size and duration and stomatal regulation. Escape mechanisms were linked to hastening of phenological stages. The intercropping of bambara groundnut with taro and maize was shown to be feasible and productive under rainfed conditions. In addition, bambara groundnut has potential to serve as a dual purpose crop - human and animal feed. Application of the AquaCrop model for bambara groundnut and the taro landrace confirmed their adaptation to low water availability. Bambara groundnut is a drought tolerant underutilised legume with potential to contribute to food security in marginal production areas. It also performs well when intercropped with other crops suggesting that it is suitable for multi-crop systems. However, the poor seed quality in landraces may make them unattractive to farmers. The use of conventional and modelling approaches can assist in generating data over a short period of time, thus saving cost and time. There is a need to promote breeding programmes aimed at developing improved lines for bambara groundnut.

Paper Number: 1074 (Poster Number: 18)

Genetic Diversity, Symbiotic Efficacy and Abiotic Stress Tolerance of Indigenous Rhizobia Nodulating Soybean (*Glycine max* [L.] Merrill) in the Mpumalanga, Limpopo and Gauteng Provinces of South Africa.

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Although soybean is an important food and cash crop in South Africa, knowledge on the genetic diversity, symbiotic efficacy and abiotic stress tolerance of soybean microsymbionts in the country remains limited. Agricultural practices and a change in climate have led to an increase in the proportion of arable land affected by abiotic stress factors such as salinity, high temperature and Drought. Abiotic stress affects the survival, multiplication and symbiotic efficacy of soil rhizobia. Species that devise tolerance mechanisms often lose the nitrogen fixation ability. This study aimed at determining the genetic diversity of soybean microsymbionts from the Mpumalanga, Limpopo and Gauteng Provinces of South Africa, as well as selecting symbiotically efficient abiotic stress tolerant rhizobia for inoculant production. Diversity studies grouped isolates into six species from the genus *Bradyrhizobium* and unidentified isolates that could be novel species. Rhizobial isolates also exhibited varying tolerance to salinity, high temperature and drought stress. Isolates also exhibited diversity in terms of symbiotic efficiency, with nine isolates inducing a higher dry matter than plants fed with 5 mM Taken together, the findings could be used to boost soybean production in Africa, through selection of elite rhizobial isolates with better symbiotic performance with the soybean host.

Paper Number: 1075 (Poster Number: 19)

Molecular Diversity of Micro-Symbionts Associated with Cowpea (*Vigna unguiculata*) Varieties Across Different Agro-Ecological Regions of Mozambique.

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The adaptive mechanism of legumes to biologically fix atmospheric nitrogen (N₂) through symbiotic associations with soil rhizobia can be harnessed as low cost alternatives to chemical fertilizers for soil N augmentation. This process however, is known to vary across agro-climatic conditions, among rhizobial strains and host legumes. So far, no study has reported on the diversity and effectiveness of rhizobia nodulating cowpea in Mozambique. A total of 99 rhizobia isolates were obtained from root nodules of two cowpea varieties (IT1263 and IT18) from three locations (Muriaze, Ruace and Sussundenga) representing different agro ecological niches. Diversity studies using BOXA1R-PCR analysis placed the isolates showed six major clusters, with a very low final level of similarity (7%), while the PCR amplification of the IGS (16S - 23S rDNA) region produced single bands ranging from 258 to 1350 base pairs (bp), placing the isolates into 28 groups. RFLP analysis of the IGS region using three, 4-base cutting restriction enzymes (HaeII, HindIII and HinfI) revealed 40 IGS-RFLP patterns, thus also showing a huge diversity among the isolates. Effectivity of the isolates at fixing atmospheric N₂ was also varied, biomass ranged from 19.2g to 4.8g while nodule dry weight ranged from 1.68g to 0.27g. Assessing diversity and effectiveness of native rhizobia nodulating cowpea in Mozambique provides a knowledge base to help address soil N limitations and inform cultivation practices thereby improving yield and food security especially in rural households. In addition, highly effective site-specific rhizobium strains may be identified for inoculant production in the future.

Paper Number: 1076 (Poster Number: 20)

Screening for New Rhizobium Strains for Studying Legume Genotype x Strain Interaction in Chickpea and Common Bean in Ethiopia.

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Paper Number: 1077 (Poster Number: 21)

Improving Adaptation of Common Beans to Low Nitrogen Soils By Enhancing Nodulation through Breeding and Selection.

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Improving adaptation of common beans to low nitrogen soils by enhancing nodulation through breeding and selection

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Bean production in Central America and the Caribbean (CA/C) region is mostly conducted in small farms with numerous soil fertility constraints, especially low nitrogen (N) and phosphorous (P). Farmers often lack sufficient resources to use recommended practices to manage these constraints. One of the main alternatives for increasing adaptation of common beans to low N soils conditions is by enhancing nodulation and nitrogen fixation. Therefore, the objective of this research was to develop small red and black bean lines with greater nodulation and nitrogen fixation using recurrent selection. The research began with the screening of 180 common bean germplasm and breeding lines grown in 8" pots containing a soil: sand (1:1) substrate low in N (<0.10%) and organic matter (<2.0%). Plants were inoculated with a liquid inoculant (yeast mannitol broath) of two *Rhizobium* strains, CIAT 632 (*R. etli*) and CIAT 899 (*R. tropici*). Plants were evaluated at flowering stage using plant dry weight (PDW), vegetative vigor and nodulation (visual 1-9 scales) as selection criteria. Crosses among most promising parents were used to develop and evaluate 259 F4 families from 26 populations in Cycle 1 and 240 F4 families from 12 populations in Cycle 2. Twenty two F6 families from Cycle 2 and two check cultivars (Seda and Amadeus 77) were evaluated in a low N field and in a soil: sand beds ("bancales") during 2014 in Honduras. During 2015, eight selected lines from the 2014 trials and the two check cultivars were evaluated in Honduras and distributed as the Ensayo Regional de Fijación Biológica de Nitrógeno (ERFBN). Seed inoculation with a peat based inoculant mixture of two strains was used in the field and the "bancales" trials. In addition to nodulation and PDW at flowering, seed yield at maturity were also assessed. Advanced lines from Cycles 1 and 2 which recombine good nodulation, primarily in the crown region, with disease resistance, tolerance to drought, heat and/or low fertility, good seed quality and other desirable traits were distributed for testing to bean programs members of the CA/C Bean Research Network.

Paper Number: 1078 (Poster Number: 36)

Response of Cowpea (*Vigna unguiculata* L. Walp) to Rhizobial Inoculation and Phosphorus Application on Farmers' Fields in Minna, Southern Guinea Savanna of Nigeria.

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Abstract

Despite the increasing importance of cowpea as a food crop in Nigeria, yields on farmers' fields have remained relatively low. Poor soil fertility which is due mainly to low levels of available nitrogen and phosphorus are often cited among the major causes of low yield. In line with the above, this research aimed at exploiting cultivar differences, rhizobial inoculation and phosphorus application as means of improving nitrogen fixation and productivity of cowpea. This paper reports results of the first year trial of a three-year study presently ongoing in Minna, southern Guinea savanna of Nigeria. Three cowpea cultivars (IT93K-452-1, IT99K-573-1-1 and TVX-3236) were sown on three farmer's field during the 2015 cropping season. The treatments were three levels of rhizobial inoculation (uninoculated and inoculated either with USDA 3384 or USDA 3451 rhizobia strains) and three phosphorus rates (0, 20 and 40 kg P ha⁻¹). Data were collected on number of leaves, vine length, leaf area, leaf area index (LAI), crop growth rate (CGR), chlorophyll content, above ground biomass yield and plant nodulation. With the exception of plant leaf area and nodulation, there was no significant differences between the inoculated and uninoculated plants with respect to the other parameters measured. Leaves of uninoculated plants were significantly larger than the inoculated. Similarly, uninoculated plants had higher nodule number and weight than the inoculated. Cultivars IT93K-452-1 and TVX-3236 had the largest and the smallest leaf sizes respectively. Similar results were recorded for LAI, vine length, shoot biomass and chlorophyll content. Generally, plants that received 40 kg P ha⁻¹ produced the largest leaves irrespective of the inoculation treatments. This was however not significantly different from those fertilized with 20 kg P ha⁻¹. Similar results were recorded for the other parameters measured. The results appears to suggest that (i) the indigenous rhizobia population in the soil form better symbiosis with cowpea than the introduced ones (ii) the application of 20 kg P ha⁻¹ seems adequate for optimum performance of cowpea in this environment and (iii) cowpea cultivar IT93K-452-1 appears to be more promising than the other two cultivars.

Paper Number: 1079 (Poster Number: 22)

Isolation and Characterization of Bacterial Endophytes from Gnotobiotically Grown Marama Bean Seedlings.

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Marama bean (*Tylosema esculentum*) is an edible wild perennial legume that produces highly nutritious seeds, leaves and big tubers. This legume is native to the drought-prone Kalahari sandy regions of Namibia, Botswana and South Africa. It is a staple food for the Khoisan and Bantu people from those areas. Analysis of the nutritional profile of this plant has revealed that the seeds have total protein content comparable to that of soybean at 30-39%. In addition, the seeds have 35-43% oil content; consisting mostly of 49%:24% ratio of oleic to linoleic acid respectively. Marama bean root tubers can be as heavy as 40 kg, containing about 10-18% protein content and 25% carbohydrates. This nutritional profile, including a high content of essential amino acids lysine and tyrosine and the limiting micronutrients Ca, Mg, Fe, P, K, and Zn clearly indicates that Marama bean has the potential to be a premium source of protein and energy for many disadvantaged rural communities in southern Africa, especially in that face of climate change effects. The versatility of this legume is not limited to human nutrition alone as the foliage is very nutritious for livestock, and is produced at times of the year when other fodder is sparse and of poor nutritional quality. Marama bean oil has a profile similar to that of olive oil and is a key ingredient in traditional cosmetics. Industrially, this oil is already being touted to exceed the value of Baobab oil which currently sells at NAD800.00 per litre. Taping into this potential crop requires brutal agricultural innovation research for Africa. One big enigma that remains, however, is solving, among a lot of other unknowns, the question of the source of nitrogen that marama bean uses to synthesize the proteins in the seeds. The objective of this study was to investigate if this bean lives in association with endophytes that fix nitrogen for it to manage to harness atmospheric nitrogen while it grows in N deficient soils. In order to achieve this objective seed were carefully surface sterilised and gnotobiotically grown to 2 week old seedlings. After that bacterial endophytes were isolated using three media. After obtaining pure cultures, DNA was isolated and used as template to perform 16S rDNA and nif H PCR amplification. Using BLAST searches, 34 bacterial species from 16 genera including *Bacillus*, *Rhizobia*, *Curtobacterium*, *Pantonea*, *Microbacterium*, *Enterobacter*, and *Burkholderia* were isolated. Of these species, indole acetic acid production activity and nitrogen fixing activity was detected. From this data a conclusion can be drawn that marama bean has a high species diversity of seed associated bacterial endophytes that have plant growth promoting activity. As this work continues, we intend to prove whether indeed in marama bean, the detected N fixing bacteria perform this role of nitrogen fixation and perform in situ localization studies.

Paper Number: 1080 (Poster Number: 23)

Effect of Cropping System, Inoculant and Crops on Symbiotic N₂ Fixation in Cowpea (*Vigna unguiculata* L.), Maize (*Zea mays* L.) and Sorghum (*Sorghum bicolor* L.) Genotypes in Marapyane, South Africa.

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Combination effect of cropping system and rhizobium inoculation on the ability of the legume to contribute to nitrogen nutrition has not been widely reported under field conditions. Although intercropped legumes and cereals compete for soil nitrogen (N) thereby reducing the N concentration in legumes' rhizosphere consequently forcing the legume to depend more on fixation, intra-hole intercropping system between legumes and cereals is less researched. Thus the aim of this study was to assess the effect of cropping system and Bradyrhizobium inoculation on plant growth and N₂ fixation of cowpea planted in Mpumalanga Province in South Africa. A field trial was conducted using cowpea Pan 311 and TUv 546; maize ZM 521 and sorghum M 48 and sowing was in intra-hole intercropping and as sole cropping. The results revealed that inoculation increased the plant growth and N₂ fixation of sole planted cowpea plants whilst, the un-inoculated sole planted cowpea plants had higher soil N uptake. Furthermore, symbiotic performance and growth of cowpea was reduced by intra-hole intercropping, however, the percentage of N derived from atmosphere was increased by intra-hole intercropping. Interestingly, cowpea plants when raised in the same-hole as maize and sorghum, plant growth and symbiotic performance were higher than the inoculated counterparts possibly suggesting the presence of competitive native soil rhizobia. In conclusion, the study shows that plant growth and symbiotic performance are increased when legumes are planted solely but reduced when intra-hole intercropped with cereals.

Paper Number: 1081 (Poster Number: 24)

Faba Bean and Soybean Precursor Crop and Its Effects on Subsequent Yield and Nitrogen Use Efficiency of Maize Varieties in Western Ethiopia.

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Prolonged continuous cultivation is posed problems to soil fertility and maize production. The use of faba bean and soybean precursor crop improved subsequent maize yield. Atmospheric N₂-fixatio by faba bean and soybean-maize sequence reduce the amount of nitrogen fertilizer applied.

Significantly higher mean grain yield maize was obtained following faba bean and soybean precursor crop without and with rhizobia inoculation. Significantly higher total nitrogen uptake of 640 and 648; and 575 and 650 kg N ha⁻¹ was obtained from BH-543 and BH-661 maize varieties following soybean with 0 and 55 kg N ha⁻¹. Higher nitrogen uptake efficiency of 3382 and 4162 %; and 6167 and 9321 % were obtained from Wenchi and Jibat varieties planted following faba bean precursor crop. Higher mean agronomic efficiency and fertilizer N (recovery) use efficiency were obtained at low nitrogen fertilizer following precursor crop. Production of maize varieties following faba bean and soybean precursor crop without and with rhizobium inoculation with 55 kg N ha⁻¹ were recommended for sustainable maize production in high and mid altitude areas of western Ethiopia.

Key words: nitrogen fixation, rhizobium, soil nitrogen

Paper Number: 1082 (Poster Number: 25)

Symbiotic N Contribution and Water-Use Efficiency of Sixteen Groundnut (*Arachis hypogaea* L.) Genotypes Grown in Ethiopia, Measured Using ¹⁵N and ¹³C Natural Abundance.

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Preference session Oral

Background and justification

Symbiotic N₂ fixation is the cheapest and most effective technology for maintaining increased yields in Africa, where soil N is low and fertilizer N inaccessible to smallholder. Few smallholder farmers apply nitrogen fertilizer in Africa due to high cost and limited availability. Therefore, the inclusion of grain legumes that are efficient in symbiotic N₂ fixation is an inexpensive, feasible and sustainable alternative to expensive mineral fertilizers for increasing crop productivity.

Result and discussion

A two year field experiments were conducted in Ethiopia, to evaluate, symbiotic N contribution and water-use efficiency of 16 groundnut genotypes using the ¹⁵N and ¹³C natural abundance techniques. The results showed significant differences in grain yield, symbiotic N contribution and water-use efficiency by the 16 groundnut genotypes. The grain yield markedly varied among genotypes ranging from 598 kg ha⁻¹ to 2069 kg ha⁻¹ in 2012 and 610 to 2147 kg ha⁻¹ in 2013. The amount of N contribution also varied markedly, with values ranging from 60 kg N ha⁻¹ to 105 kg N ha⁻¹ in 2012 and 90 kg N ha⁻¹ to 176 kg N ha⁻¹ in 2013. ¹³C isotopic analysis revealed marked variations in water-use efficiency among genotypes. In 2012, higher discrimination of ¹³C in genotypes Werer-963 and Werer-964 indicated lower water-use efficiency as compared to genotypes Bulki, Nc-343 and Tole-2 which exhibited lower ¹³C discrimination indicating greater water-use efficiency, while in 2013 higher ¹³C discrimination was exhibited in genotypes Werer-964 and Sedi.

Conclusion.

The strong genotypic differences in grain yield, symbiotic N contribution and water-use efficiency can be used in selecting groundnut genotypes for enhanced grain yield, greater symbiotic performance and higher water-use efficiency.

Paper Number: 1083 (Poster Number: 26)

Effect of Selected Bradyrhizobia on Growth, Biological Nitrogen Fixation and Yield of Cowpea in Kilifi and Embu, Kenya.

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Keywords - Legumes, *Vigna unguiculata* (L) Walp, genotypes, Biological Nitrogen Fixation, nodulation

The interaction of cowpea with efficient strains of rhizobia in Biological Nitrogen Fixation can allow increased yield, which can completely replace Nitrogen fertilization and can reduce production costs. The aim of this study was to evaluate the effect of 3 cowpea genotypes (M66, K80 and Black eyed pea) to inoculation with 4 rhizobia strains (K1h, M19c, BR 3262 and BR3267) in a greenhouse experiment conducted in IITA, ICIPE Duduville Campus, Nairobi, Kenya. The best strain-cultivar combination were further selected from the initial greenhouse experiment to determine the effect of 5 Phosphorus levels in the form of Sympal (0, 15, 30, 45 and 60 P₂O₅) application on their growth, Biological Nitrogen Fixation and yield in the greenhouse then further validated under field conditions. The treatments were laid in a Complete Randomized Design with 4 replications. Black eyed pea variety produced significantly, the highest values for nodulation growth and yield. Agronomically, application of 30KgP/ha was significant (P<0.05) with enhanced shoot and root dry weight, total biomass, number of nodules, N and P uptake of cowpea genotype investigated and is therefore recommended. Strain authorized as inoculant BR 3267 promoted yields that were higher compared to strains under selection (K1h and M19C).

Thus it would make sense to promote the utilization of BR 3267 strain performing well with the Black eyed pea which is a local variety to result to improved BNF and yield for poor farmers.

Paper Number: 1084 (Poster Number: 27)

Assessment of Growth, Nodulation and Yield of Cowpea (*Vigna unguiculata* L. Walp) Sampled from Farmers Fields in Northern Mozambique.

*Margarida Graciete Simbine**, *Sipho Thulane Maseko*, *Sanjay Jaiswal* and *Felix Dapare Dakora*, *Tshwane University of Technology*

In Mozambique cowpea is widely grown by smallholder farmers. It represents a good source of calories, protein and mineral nutrients for human nutrition and health. Despite being source of nutrition it enhances soil fertility through the biological nitrogen fixation process, a process that provides a relatively low-cost in replacing fertilizer-nitrogen in the soils. When cultivating cowpea and other legume and cereal crops, majority of smallholder farmers in Mozambique do not use inorganic fertilizers for improving soil fertility and productivity of their farms due to high costs and accessibility, further, farmers hardly practice livestock farming so there is hardly organic manure used as supplements. Growth, nodulation and yields of cowpea (*Vigna unguiculata* L. Walp.) genotypes grown under farmer's field conditions was assessed during the 2014/2015 farming season. A total of twelve fields were established in three sites, Mecuburi, Mahula and Mulapane in Nampula province, Northern Mozambique. The trial design adopted was the, one-field, one-replicate (Fielding and Riley, 1998), with a minimum four replicates per site. Four treatments, cowpea varieties, IT-16, IT-18, Sudan-1 and Local (Namuruwa) were tested. Analyses of variance revealed significant differences in shoot dry matter, nodulation and grain yield. Variety Sudan-1 recorded the highest shoot dry matter, 1.85g plant⁻¹ while IT-16 recorded the lowest 4.06 plant⁻¹. Nodulation was high in local variety, 27 nodules plant⁻¹ and low in IT-16, 10 nodules plant⁻¹. Highest grain yield was recorded in variety Sudan 1 (462kg ha⁻¹) and the lowest in Local variety in (122kg ha⁻¹). In general, the results show that variety IT-18 is the best candidate for inclusion in smallholder farming systems in Nampula, Mozambique to improve yield and soil fertility.

Keywords: Cowpea, smallholder's farmers

Paper Number: 1085 (Poster Number: 28)

Nitrogen Fixation, Water-Use Efficiency and Nutrient Density in Grain and Wild Legumes from Different Parts of Botswana.

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In Botswana, poor soil fertility and low soil moisture are the major constraints to arable agriculture. Methods of correcting them include inorganic fertiliser addition and irrigation. Mineral fertilisers are out of reach for resource-poor farmers and are known to pollute the environment while water is scarce. The legume/rhizobia symbiosis, where members of Rhizobiales and some proteobacteria belonging to the genus *Burkholderia* form a mutual relationship with some members of the plant family Leguminosae is known for its contribution in N cycling under agricultural and natural systems. Besides N cycling, recent studies have indicated that nodulated legumes comparatively uptake higher amounts of soil nutrients. Also, legumes such as cowpea (*Vigna unguiculata* L. Walp) and Bambara groundnut (*Vigna subteranea* L. Verdc.) have been said to be water-use efficient. In this study, cowpea, Bambara groundnut and some wild herbaceous legumes were sampled from farmer's fields in the Okavango Delta and Tswapong areas of Botswana. Plants were tested for their ¹⁵N and ¹³C signatures as well as for macro and micronutrient content to measure their level of N₂ fixation, water-use efficiency and nutrient density respectively. Significant variations were found in N₂ fixation and water-use efficiencies of legumes within and across regions. Differences were also found in the nutrient uptake by the legumes from various locations. Results from this study offer insight for N cycling under dry areas, also giving an opportunity to select legume genotypes with high N₂ fixation, high water-use efficiency and high nutrient densities.

Keywords; biological nitrogen fixation, effectiveness, efficiency, nutrients

Paper Number: 1086 (Poster Number: 29)

Symbiosis Induced Mineral Accumulation in Inoculated Soybean Genotypes Grown Under Field Conditions at Two Experimental Sites in South Africa.

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Food fortification with micronutrients has been shown to be an important method of combating malnutrition. Legumes however, provide a cheap and sustainable means to bio-fortify foods. Symbiosis between legumes and rhizobia may influence the chemistry of nutrients in soils, thereby enabling uptake. Using promiscuous soybean genotypes (genotypes capable of forming symbiosis without inoculation), an experiment was set up to assess the relationship between symbiosis and nutrient accumulation in selected soybean genotypes. Data revealed marked differences in nitrogen fixation and nutrients accumulated in shoots of the test genotypes. At Marapyane site, ^{15}N values ranged from +0.32 to -1.85‰. Genotypes TGx1835-10E, TGx1990-116F amongst others recorded low ^{15}N values and accumulated high amounts of nutrients in their shoots. At Nelspruit site, ^{15}N values ranged from -0.17 to -2.07‰, with genotypes such as TGx1988-25F and TGx1448-2E accumulating high amounts of nutrients in their tissues. Generally, the un-inoculated promiscuous genotypes at Marapyane fixed higher amounts of N, and accumulated higher amounts of nutrients in their tissues. In contrast, inoculating the test genotypes at Nelspruit resulted in increased N fixation and nutrients accumulation in shoots. These findings suggest that, enhanced Nitrogen fixation either as a result of the inoculation with rhizobia or through symbiosis with indigenous rhizobia resulted in increased nutrient accumulation in shoots of the test genotypes. Legumes such as soybean through their symbiosis therefore have the potential to address nutrient deficiencies in Africa.

Paper Number: 1087 (Poster Number: 30)

Cowpea Yield Responses to Inoculation and P Fertilization in Different Environments.

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Cowpea is an important food crop and essential component of the cropping systems in arid and semi-arid regions of Mozambique. It is a major source of dietary protein for both rural and urban poor. Despite its importance yields are very low due in part to limited access to improved varieties and lack of information on better crop and soil management practices. The objectives of this study were to assess the effects of inoculant and P on nodulation, N accumulation and yield of two cowpea cultivars in three agro-ecological zones of Mozambique. Field experiments were conducted on clay loam and sandy clay loam soils at three locations during the 2013/14 and 2014/15 growing seasons. Randomized complete block design with four replications was used. Treatment consisted of seed inoculation before planting, application of 40 kg P₂O₄ ha⁻¹, combination of the two factors and a non-inoculated control. Inoculation improved nodulation and yield in both cowpea cultivars across locations but P improved yield at only one location in 2013/14. Inoculation alone significantly enhanced cowpea grain yield more than applying P alone and there was no significant yield difference between inoculation alone and applying inoculant and P together during the first year. In 2014/15, inoculant and P increased cowpea yield but the increase due to P was higher than that for the inoculant. Significant positive interaction between the inoculant and P occurred in 2014/15 in contrast to that for the previous year. The highest yield advantage for applying inoculant or P alone or in combination ranged from 625 -1050 kg ha⁻¹.

Paper Number: 1088 (Poster Number: 31)

Rhizobium Inoculant Irj 2180A Suppresses Striga Emergence and Increases the YIELD of Cowpea in Highly Infested Environment.

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is the grain legume crop of high agronomic, nutritional and economic importance in the semi-arid tropics where it is mainly cultivated by small holder farmers. Despite its adaptation to drought-prone, warm and poor soil environment, cowpea is highly infested and devastated by the parasitic weed (*Striga gesnerioides* Vatke (Willd)) which is by far the most biological constraint to the crop production in the savannah. Experiments were conducted in both field and screen house with the objective to evaluate the potential of Rhizobia inoculant (USDA 3348, IRJ 2180A) and urea in mitigating *Striga* in the root tissue of its host. No significant effect of Rhizobia and urea application was observed on leaf chlorophyll content.

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Number of nodules for all tested genotypes was significantly increased by inoculant IRJ 2180A for tolerant and susceptible lines in both environments. IRJ 2180A inoculant highly suppressed *Striga* emergence in both environments ranging from 44 to 100 percent reduction. None of the treatments had positive effect on plant fodder yield except IRJ 2180A which also enhanced pod and grain yield. The study shows *Rhizobium* has an impact on *Striga* infestation. There is need of further research in order to explore the potential of our indigenous *Rhizobium* in the biological control of *Striga*.

Key words: *Vigna*, *Striga*, *Rhizobium*, growth, yield, adaptation, water deficit

Paper Number: 1089 (Poster Number: 32)

Role of P Fertilization and Rhizobium Inoculation on Plant Growth, N Accumulation, $\delta^{15}N$ and GRAIN YIELD of Two Soybean (*Glycine max* (L.) Merr.) Varieties Grown in Two AGRO-Ecological ZONES of Mozambique.

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P-supplementation in addition to rhizobium inoculation has contributed significantly to plant growth, symbiotic n₂-fixation and grain yield. However, little is known about this agronomical practice by smallholder farmers in Mozambique. This study assessed plant growth, n₂-fixation and grain yield of two soybean varieties as affected by P and rhizobium inoculation at Muriaze and Ruace in 2011 cropping seasons. Field experiment was undertaken using split-plot design with 4 replications. The treatments consisted on two soybean varieties Zamboane (promiscuous) and Storm (non-promiscuous), two levels of peat-based inoculant (RI0 and RI1) and phosphorus (0 and 40 kg ha⁻¹). P was applied in main plots and the combination of varieties and inoculation became subplots. Nodules and shoots were sampled at flowering stage. Shoots were processed to estimate n₂-fixation using $\delta^{15}N$ natural abundance technique and grain yield was calculated at harvesting. AnOVA showed significant interaction between factors for most of parameters studied. The combinations of P+RI significantly produced the greatest nodule and shoot dry mass, n-accumulation and lowest $\delta^{15}N$ for both variety across locations. As a result %Ndfa, n-fixed and grain yield were much higher with P+RI. The n-fixed increased from 39.2 to 127.4 kg/ha at Muriaze and 108.3 to 320.4 kg/ha at Ruace from control and P+RI respectively and Variety Zamboane did better across locations. Based on the results it was concluded that to boost soybean production in Mozambique seeds inoculation with compatible strain together with P-fertilizer is crucial to achieve the potential yield ensuring soil sustainability under rain fed conditions.

Keywords: P-supplementation, rhizobium inoculation n₂-fixation $\delta^{15}N$ and %Ndfa

Paper Number: 1090 (Poster Number: 33)

Enhancing Cowpea Productivity in the Sahelian Zone of Niger: The Contribution of Composted Millet Glume and Mineral Fertilizer.

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The use of composted millet glume in crop production is gradually gaining popularity among smallholder farmers in Niger. Nonetheless, there is virtually no scientific research on its influence on Biological Nitrogen Fixation (BNF) and cowpea grain yield. Thus, working on the hypothesis that complementary application of organic and inorganic fertilizers will enhance BNF and cowpea yield, a study was conducted at N'dounga research station, Niger, to assess the amount of nitrogen fixed in cowpea under millet glume compost and N and P fertilizers. The results showed that 3 t/ha compost+ 15 kgN/ha+26 kgP/ha produced the highest cowpea grain yield (2764 kg/ha). In addition, 3 t/ha compost+ 15 kgN/ha+26 kgP/ha gave the highest nitrogen (123.5%) and phosphorus (16.8%) use efficiencies. Correlation analysis showed a strong positive relationship ($R^2 = 0.84$) between cowpea grain yield and amount of nitrogen fixed. A strong positive correlation ($R^2 = 0.98\%$) was observed between grain yield and amount of nitrogen fixed. The proportion of nitrogen derived from the atmosphere (Ndfa) in cowpea ranged from 33–78%. Amount of nitrogen fixed was highest (69.57 kg/ha) under 3 t/ha compost+ 15 kgN/ha+26 kgP/ha. The combined application of composted millet glume and mineral fertilizer in an integrated nutrient management strategy can be the best alternative for smallholder farmers in the study area if higher yields of cowpea and N fixation are to be obtained. It is however recommended that, the quality of the millet glume compost and its value as fertilizer be evaluated under long term crop response trials.

Paper Number: 1091 (Poster Number: 34)

Benefits of Inoculation, P Fertilizer and Manure on Yields of Bean and Soybean Are Also Seen in Increased Yield of Subsequent Maize.

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Smallholder farmers grow bean and soybean without fertilizer addition and expect improved grain yield even in the subsequent cereals in rotation. This study evaluated the benefits of inoculation, P fertilizer and manure on yields of bean and soybean, and how these benefits are translated in increased yields of a subsequent maize crop. Bean variety RWR 2245 and soybean variety SB 24 were tested in two districts. The treatments included inoculum, three rates of manure and two rates of P fertilizer, and were laid out in a split-split plot design with three replications. The two legumes responded well to inoculation when manure and P fertilizer were added. Grain yields varied from 1.7 t ha⁻¹ and 1.6 t ha⁻¹ in unamended control plots to 3.7 t ha⁻¹ and 3.8 t ha⁻¹ in inoculated with P and manure addition plots for bean and soybean respectively. Yields of maize grown after soybean varied from 1.7 t ha⁻¹ in control plots to 4.6 t ha⁻¹ in previously amended plots. Maize yields after bean varied from 2.2 t ha⁻¹ in control plots to 5.6 t ha⁻¹ in treatments previously inoculated with P and manure addition. The use of inoculum combined with modest amount of manure and P fertilizer are good option for smallholder farmers growing bean and soybean in rotation with maize.

Paper Number: 1092 (Poster Number: 35)

Symbiotic Efficacy and Tolerance of Soybean Rhizobia to High Temperature and Drought Stress.

Akech Violet, Makerere University*

Successful production of soybean in areas with none or insufficient numbers of indigenous rhizobia requires the use of commercial rhizobial inoculants. The infectivity of applied inoculants is affected by high temperature and drought stress. The two stresses are prevalent in arable land due to changing climatic conditions, attributed to global warming among other factors. Tolerance to drought and high temperature are desirable traits of any commercial inoculants, besides being symbiotically efficient. This study aimed at selecting symbiotically efficient soybean rhizobia tolerant to drought and high temperature stress. Results on symbiotic efficiency identified rhizobial isolates with a high symbiotic effectiveness index. Drought and high temperature tolerance studies identified tolerant rhizobial strains. In general, symbiotically efficient rhizobial isolates tolerant to high temperature and drought stress were identified. Such rhizobial isolates can be used in the production of inoculants for use in high temperature and drought stricken areas, to boost soybean production.

Paper Number: 1093 (Poster Number: 37)

Impact of Improved Technologies on Yield and Income of Smallholders Farmers in South Kivu.

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In South-Kivu, agriculture is hindered by demographic outburst driving to small size land and degradation of natural resources which is leading to nutrient depletion. This decreasing of soil fertility due to low input and loss of nutrients affect the crops production. N2Africa-Project supported farmers with improved technologies since 2009 such as improved seeds, Rhizobium inoculum and small mineral-fertilizers quantity. Training sessions for farmers was scheduled in order to transfer knowledge on crop and soil fertility management that aimed to empower them with sufficient skills so that they can increase the beans, soybeans and groundnuts yield up to 954 kg.ha⁻¹ and the household income to 465\$. The goal of this study was to assess the early impact of these technologies on production and household income and questioned whether these technologies has produced the expected effects on households in 4 territories of South Kivu province namely Walungu, Kabare, Mwenga and Uvira. The stratified sampling method was used for sampling. Target population was divided into 13 sub-set of action. Each of which is a stratum based on two criteria, namely the agro-ecological potential and market access. Logit model was used to estimate the determinants of the spread based on technologies which the treatment effect approach was applied to assess the impact on production and income. Results showed that the N2Africa-project technologies had a positive impact on farmer agricultural production and their household income. An average increase of 400 kg.ha⁻¹ for beans and 115kg.ha⁻¹ for soybeans across the subpopulation of adopters have been recorded.

Paper Number: 1094 (Poster Number: 38)

Nodulation Performance Under Controlled Conditions of Experimental Inoculants for Chickpea Performing Pre-Sowing Seed Treatment.

Fabio Montero and Guido Ramirez Caceres, Rizobacter*

Biological nitrogen fixation by *Mesorhizobium ciceri* can contribute with up to 80% of the N requirements of a chickpea crop, thus leading to lower fertilizer use, a consequent decrease in its carbon footprint and a more sustainable agricultural system. Handling and application of inoculants is a process many times exposed to stressful environmental conditions for bacteria. Pre-treatment of seeds before sowing is a valuable feature for seed companies and small retailers interested in delivering a ready-to-use product. A proper amount of bacteria should be placed on each seed in order to assure once they are planted and germination starts, the symbiotic process gets started and nodulation occurs. In this trial, chickpea seed was treated with 4 different experimental osmo-protected inoculants and stored for up to 41 days. During this period of time cfu/seed and nodulation assessments in growth chamber were performed at 1, 10, 22, 30 and 41 days after inoculation (dai). From 1 to 41 dai, cfu/seed counts significantly decreased in all 4 treatments progressively. This was not equivalently observed in the nodulation assessments, where performance varied both within inoculants and pre-inoculation time. Even though all inoculants showed a common behavior, inoculants 1 and 4 outperformed inoculants 2 and 3 when focusing in dry nodular mass differences between 1 and 41 dai. Future work will be carried out at lab, growth chamber and field in order to validate the results obtained as well as the compatibility with seedcare products.

Paper Number: 1095 (Poster Number: 39)

Abstract the Role of the Private Sector in Increasing Adoption of Post-Harvest Management Technologies By Smallholder Farmers: The Experience of the PICS Bags Project.

Jean Njiru and Dieudonne Baributsa, Purdue University*

Purdue University is implementing the Purdue Improved Crop Storage program in several countries in Sub-Saharan Africa and Asia. The goal of the program is to reduce post-harvest losses, estimated at 30%, using hermetic technologies. The PICS technology is a simple, low-cost, and effective triple layer bag that enables farmers to preserve their grains without use of insecticides. The PICS bags increase farmers' income and improves food security. To commercialize the PICS bags, Purdue has partnered with the private sector including plastic manufacturers and distributors of agricultural inputs, and service providers including the government extension services to build the demand of the bags. The private sector partners produce and sell PICS bags to smallholder farmers through networks of vendors. By June 2015, training activities on the proper use of the PICS bags were implemented in more than 40,000 villages. More than 5 million bags were sold to farmers in Sub-Sahara Africa and Asia. Despite these progress, challenges remain including improving the PICS bag availability in small shops and in rural areas. Sustained availability of the bags requires an effective supply chain that ensure farmers have timely access to the bags in local markets during harvesting. This presentation will discuss the efforts to develop the supply chain for the bags and, challenges and opportunities in sustaining reduction of postharvest storage losses among smallholder farmers.

Paper Number: 1096 (Poster Number: 40)

Situation Analysis of Common Bean Production, Marketing and Consumption in Malawi.

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ABSTRACT

Common beans are recognized as an important source of vegetable protein and income for smallholder farmers in Malawi. However current production yields are not sufficient to meet local demand and export. Therefore there is need to understand the current status in terms of production, marketing and consumption in Malawi. The study employed a trend analysis, double exponential and SWOT analysis. The study revealed that production and area have an increasing trend while yield display a decreasing trend. Prices of common beans and other major pulses also display an increasing trend. In addition, per capita consumption also displays an increasing trend. The SWOT analysis revealed that there is unpredicted weather condition affecting productivity, lack of clear policies 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 concluded 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 and institute advocacy for policies that promote production and marketing of common beans. The study will contribute towards attainment of Malawi national food security goals, as common beans are expected to remain in the food security equation.

Paper Number: 1097 (Poster Number: 41)

Traditional Markets in Nicaragua: Their Current and Potential Role to Deliver on Income Generation and Food Security for Poor Bean Producers and Consumers.

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Mainstream research has mostly focused on understanding the functioning of the formal market value chains. However, most producers serve low-resource consumers through traditional (wet or informal) markets and their potential to deliver on income generation for producers and food security for consumers could be important. This paper focuses on studying the current role of traditional markets for red beans in three main cities of Nicaragua, their potential to generate higher income and food security for low-resource producers and consumers, and assessing the inclusiveness of existing business models in these markets. The cities of interest are Managua and two increasingly urbanized and rapidly growing cities (Esteli and Matagalpa), and the analysis compares the results both within and between cities. Primary data was collected from traders (intermediaries, wholesalers and retailers) using structured questionnaires. Most of the analysis was done using descriptive statistics but principal component analysis was used to analyze inclusiveness. Our findings show that there are large differences in the characteristics of traders within and between cities, and that business models in secondary cities tend to be more inclusive than in the capital city. Results significantly contribute to the debate in this topic and provide insights on how traditional markets are structured, who the actors are, their relationships among them and how issues like governance, economic returns and access to services are managed. Further, they provide an empirical base for policy recommendations aimed at improving their efficiency.

Paper Number: 1098 (Poster Number: 42)

Pathways for Generating Socio-Economic Benefits from Bean Value Chain Development at Maendeleo Innovation Platform, Eastern DRC.

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The common bean, *Phaseolus vulgaris*, is the most important pulse crop in DRC and one of the most important food crops in the country. Notwithstanding its importance in the economy, beans have not generated sufficient socio-economic benefits for its producers who constitute 85% of the farmers in the country. This study is aimed towards identifying pathways for generating socio-economic benefits that could arise from bean value chain development using the case of Maendeleo IP in North Kivu Province, Eastern DRC. The study analyses the socio-political context of the country, input and output markets in the province, and the value chain functions and benefits at the IP. Compared with neighboring countries, it is shown that bean production in the DRC is very low, making it difficult to penetrate regional markets. This is partly attributed to weak central government interventions that cannot permit fair competition with countries in the region that heavily subsidize agricultural inputs. Although there is no bean processing infrastructure in the province, local bean markets abound especially in Goma consumption basket. The pathways for generating socio-economic benefits lie in innovatively improving the efficiency of the existing bean value chain to exploit the local markets. Key innovations include inorganic / organic fertilizer combinations, intercropping systems, providing market information and business skills. The results of generating economic benefits from this most important food crop would strengthen and anchor beans as the most versatile and amenable legume crop in this region. This is already being demonstrated in the Maendeleo IP multi-stakeholder partnerships.

Paper Number: 1099 (Poster Number: 43)

Value Chain Policy Support for Improved Performance of Smallholder Grain Legume Farmers in Zimbabwe.

Freeman Gutsa, Dumisani Kutwayo and Danisile Hikwa, Department of Research and Specialist Services*

Value Chain Policy Support for Improved Performance of Smallholder Grain Legume Farmers in Zimbabwe Gutsa Freeman ; Dumisani Kutwayo and Danisile Hikwa Abstract Notwithstanding their high nutritional value, nutritional benefits and farmer level production remunerations, grain legumes are not ranked high on the food hierarchy, policy and institutional support in Zimbabwe. Grain legume farmers and their supply chains are confronted by the challenge of how to sustainably enhance their competitiveness, efficiency and profitability in the absence of clear policy and institutional support. The major policy focus in Zimbabwe has been on maize, soybeans, cotton and horticultural crops at the expense of the grain legumes.

Policy and institutional analysis conducted through a combination of desk study and individual household interviews showed that improved policy support contributes at least 30% towards the value of production and productivity increase of grain legumes among the smallholder farming communities. There was evidence that structured policy support brings relief and defines the main pathway out of poverty for poor grain legume farming households and provides innovative and unique linkages that bring smallholder producers and public and private stakeholders together to help achieve the underlying objectives of enhancing production and productivity. The findings from this study suggest that policy and institutional support influence grain legume production among the smallholder farming communities and can be used in the crafting of improved policies which facilitate and enhance sustainable increase of legume production and profitability along the value chain. This study thus sets the tone for the impact of improved policies and the definition of a set of policy options to support grain legume production along the value chain.

Paper Number: 1100 (Poster Number: 44)

The Economics of Rhizobium Biofertilizer Utilization Among Small-Scale Farming Systems in Zimbabwe and the Role for Policy.

Freeman Gutsa, Department of Research and Specialist Services*

The Economics of Rhizobium Biofertilizer Utilization Among Small-Scale Farming Systems in Zimbabwe and the Role for Policy Gutsa Freeman Soil Productivity and Research Laboratory under Chemistry & Soils Research Institute is the sole producer of rhizobium biofertilizers in Zimbabwe. The factory has a capacity of producing more than 200000 by 100g sachets and contributing immensely to the success of the grain legume subsector. With this potential production size (latent in nature) of rhizobium biofertilizers in Zimbabwe, adoption, diffusion and utilization of the technology is still very low (currently below 50 000 sachets per season) and is threatening not only the production system for the biofertilizer but the cause for the production effort as well. The study has shown that 57.3% of the farming communities are aware of the rhizobium inoculant technology but only 12.24% are still using it. This raises questions regarding performance of the biofertilizers because 17.72% of the farmers indicated that they once used the technology but are no longer using it. Adopting a new technology comes along with risks and the magnitude of these risks is determined by the amount of information made available before adoption. The results depicts that adoption can be very low if the following issues are not addressed; a). Awareness, b). Availability, c). Provision of information, d). Institutional and policy support for the production of the respective crops which indirectly through derived demand will lead to enhanced utilization of the input (new technology). The study carried out is of prime importance in determining better ways of ensuring increased rhizobium biofertilizer utilization and hence sustainable grain legume production especially in the small-scale farming communities

Paper Number: 1101 (Poster Number: 45)

Impact Des Plateformes D'innovation Dans La Chaîne De Valeur Niébé Grain Sur La Sécurité Alimentaire Et Nutritionnelle En Afrique De L'ouest.

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Le niébé est l'une des principales légumineuses produites et consommées dans la sous-région Ouest Africaine. Son importance économique, son taux élevé en protéine et son importance dans le régime alimentaire des populations, font de cette culture un élément important de la sécurité alimentaire et la réduction de la pauvreté. Malgré les efforts fournis, la chaîne de valeur niébé grain est confrontée à certaines contraintes (FAO, 2015) au Ghana, Mali, Nigéria et Sénégal. La méconnaissance du marché est l'une des principales contraintes auxquelles les regroupements sont confrontés. A cela s'ajoute, le manque de liaison entre les différents acteurs de la chaîne. L'objectif général de l'étude est d'analyser l'impact de la chaîne de valeur niébé grain sur la sécurité alimentaire et nutritionnelle par la diffusion des innovations. Comme hypothèses de l'étude, la chaîne de valeur niébé grain permet d'augmenter le revenu et contribue à l'accès aux marchés. Le modèle Logit est utilisé comme outil d'analyse dans les zones d'étude du projet. Les résultats ont permis de mettre les différents acteurs en une chaîne de valeur puis en une plateforme d'innovation. Ceci a permis une diffusion à grande échelle des innovations. On a constaté une augmentation du revenu via les conditions de vie des différents acteurs. La recherche a permis d'identifier les marchés potentiels et les circuits de commercialisation et de consommation. Comme recherche future, faire un suivi-évaluation des différentes plateformes d'innovation installées et un renforcement de capacités des acteurs.

Mots clés : Niébé, sécurité alimentaire et nutritionnelle, chaîne de valeur, plateforme d'innovation,

Paper Number: 1102 (Poster Number: 46)

Challenges and Opportunities in Bean Production and Marketing in Selected Bean Corridors in Kenya.

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Beans are mainly consumed without much processing although value addition processing through precooking alludes to many benefits. Challenges in common bean production have been attributed to increasing severity of production constraints, amongst them erratic and poorly distributed rainfall patterns, continuous use of poor genetic materials coupled with incidences of field and storage pests, degraded natural resources - especially declining soil fertility. A study was carried out to characterize current status of common bean production and potential opportunities for increased adoption and production of common bean and marketing in selected bean production corridors in Kenya. This paper explores both the challenges and emerging opportunities from analysed survey data of 440 respondents selected using a multi-stage random sampling procedure. Study findings show that labour distribution across bean production activities were predominantly carried out either by male and female household members. Over 86% of male respondents did most of land preparation - could possibly imply a major challenge for female-headed households. Bean sorting was done mostly (91%) by women. Up to 50% of the respondents said crop farming was their main source of household income. Challenges associated with bean market were trekking for long distances to sell farm produce and procure farm inputs. Value-addition of beans at industrial level can enhance both household income and nutrition. Similarly, promotion and commercialization of bean production through well established public-private-partnership platform such as community production and marketing system (COPMAS) has great potential to further enhance improved household income, food security and nutrition.

Paper Number: 1103 (Poster Number: 47)

Understanding Value Chains That Supply Nutrient Dense Foods to Urban and Peri-Urban Consumers in Kenya and Uganda through Informal Markets.

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The project 'Understanding value chains that supply nutrient dense foods to urban and peri-urban consumers in Kenya and Uganda through informal markets' aims to upgrade bean value chains to create a win-win situation for the rural and urban poor by expanding the production and consumption of more nutrient dense bean-based foods. By increasing the consumption of these foods, delivered through market-based solutions, the diets of vulnerable rural and urban consumers in Kenya and Uganda will be improved. The project specifically targets women of reproductive age and children 6-59 months old. The project applies an interplay of three methodological approaches: (1) micro-level evidence based on value chain and consumer surveys; (2) meso-level evidence based on semi-structured interviews with key informants; and 3) macro-level evidence based on major, recent and relevant (inter)national indicators and policies. By researching both supply side and demand side constraints, and food safety and losses among the bean value chain, information is provided on how informal national and sub-national market channels function for nutrient dense beans. The project facilitates participatory processes that stimulate the uptake of nutrition-sensitive tools, methods, and technologies generated for analyzing and upgrading bean value chains in Kenya and Uganda by project partners in national research and innovation systems. Additional projects will allow to reach 50,000 rural and urban vulnerable consumers with affordable nutrient dense bean-based food products sourced from local farmer organizations, with the potential of reaching 2 million consumers in Uganda and 3 million consumers in Kenya by 2020.

Paper Number: 1104 (Poster Number: 48)

Estimating Common Bean Consumption Demand in Uganda.

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Pulses are vital for nutrition security and considered a cost-effective option for improving the diets of low-income consumers in developing countries. Sub-Saharan Africa has the highest proportion of people living in extreme poverty and highest per capita pulse consumption in the world. Most studies on pulse demand have largely depended on aggregated data at regional level and there is little information on household level consumption patterns across sub-population groups within the same geographical location. This study uses the most recently collected LSMS-ISA data in Uganda, which is nationally representative, to analyze household bean (*Phaseolus vulgaris* L.) consumption demand and unmask differences between poorer and wealthier consumers in urban and rural localities. Household spending on bean increases with income and is about three (two) folds greater among wealthier households compared to the poorest ones in rural (urban) areas. However, food budget share spent on bean declines as income grows. As household food expenditure increases, as a result of higher income, demand for bean increases, however the magnitude of this increment decreases as income rises. Demand for bean among poor households is much more responsive to changes in price compared to non-poor households, making the former more vulnerable to price volatility.

Findings will allow to assess growth in bean demand as the country develops and income grows. It will also allow to simulate changes in consumption following production shocks and price changes and whether household food security of the poor is threaten as a result.

Paper Number: 1105 (Poster Number: 49)

The Importance of Legumes in the Ethiopian Farming System and Overall Economy: An Overview.

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Crops, livestock and trees are major components of farming systems in Ethiopia. Crop production is dominant in Ethiopian agriculture as well as in the farming system. Legumes are among the various crops produced in all regions of the country in different volumes after cereals. More than twelve legume species are grown in the country. Pulses production by volume has been increased by 71.92% for the duration of nearly 20 years and with a growth rate of 3.78% per annum. Area coverage by pulse crops for the same period grown by 53% with a growth rate of 3% per year. Total pulses grain yield, which is volume of production per unit area, showed good increment from 8.79 quintals per hectare in the cropping year 1994/1995 to 14.76 quintals per hectare in 2012/2013 cropping season. However, it is much lower compared to the potential demonstrated in research managed fields. Legumes have multiple uses. Grain legumes provide food and feed and facilitate soil nutrient management. Herbaceous and tree legumes can restore soil fertility and prevent land degradation while improving crop and livestock productivity sustainably. The pulse industry in the country has developed significantly with little intervention, and great potential exists to increase the production and impact of pulses through proactive and targeted support. The role that Ethiopia now plays in the international pulse market can be attributed to significant growth rates in pulse production over the last nearly 20 years. However, bunch of constraints and considerable gaps lean the legumes along the value-chain from production to marketing and utilization. The country needs to target the constraints and gaps to optimize the importance of legumes in the farming system and economy of the country.

Keywords: Ethiopia; farming system; legumes/pulses; sustainability.

Paper Number: 1106 (Poster Number: 50)

Improved Storage Structures for Post-Harvest Handling of Cereal and Pulses in Mozambique and Zambia.

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Food and nutrition security in Sub-Saharan Africa (SSA) remains at risk due to the volatility and rapid increases in food prices, natural disasters and climate change effects. Post-harvest losses (PHL) at smallholder farm level are some of main challenges in most of SSA. For instance, the PHL of cereal and pulses are reported to be over 20%, thereby contributing significantly to food insecurity in rural and urban households in Mozambique and Zambia. PHL in SSA can be attributed to poor storage infrastructure. One of the most sustainable ways to ensure crop productivity, food and nutrition security is to reduce PHL and simultaneously lower the burden on the environment. This can be achieved by use of storage infrastructures such as Polyethylene and metal silo tanks, (PST and MS) apart from the Local grain bag (LGB), which have not been largely promoted in SSA. On-going trials in parts of Mozambique and Zambia, differentiated by climatic conditions, show that there is no sign of infestations as the number of pests is decreasing with every sampling compared to the baseline data in maize and cowpeas/common beans in PST and MS compared to the LGB. This reduction in PHLs will promote an adequate supply of quality grain legumes which are useful for protein sources and nitrogen-fixation for improved soil fertility Therefore, further research on these technologies must be done to check for grain quality after long time storage, among others. Currently, research is being done on-farm to validate the technologies' performance.

Paper Number: 1107 (Poster Number: 51)

Effects of Packaging Material and Seed Treatment on Weevil (*Callosobruchus maculata* (F) Coleoptera: Bruchidae) Infestation and Quality of Cowpea Seeds.

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This study was conducted to determine the effects of seed treatments using Neem leaf powder, pepper fruit powder, camphor, groundnut oil and wood ashes in combination with five different packaging materials (cloth bag, paper bag, glass bottle, polythene and plastic container) on the viability of cowpea seeds. Dried seeds of cowpea (11% mc) were treated and stored for 6 months using different packaging materials. The experiment was laid out in a Completely Randomize Block Design with 3 replications. Results obtained from the study showed that packaging material and seed treatment had highly significant effect ($P < 0.001$) on the vigor and germination percentage of cowpea seeds. Seeds stored in Plastic containers had the highest vigor and germination percentages (61.1% and 77.1% respectively) followed by glass bottle (60.3% and 72.2%). Seeds stored in cloth bags had lowest vigor and germination percentages (43.4% and 53.3% respectively). Seed weight was positively correlated with vigor and germination percentage ($r = 0.6$). The seeds ($n = 100$) that were stored in plastic containers had higher seed weights after 6 months due to low percent seed damage and weevil severity score. The results also show that the vigor and germination percentage were influenced by seed treatment. Germination percentage of seeds treated with powdered pepper (73%) and neem leaf powder (72.5%) were significantly ($P < 0.05$) higher than other treatments. Therefore, for short term storage of cowpea it is better to store seeds in plastic containers and glass bottle in combination with dry powdered pepper or neem leaf powder to maintain seed viability.

Key words: Cowpea, packaging material, seed treatment, vigor, germination

Paper Number: 1108 (Poster Number: 52)

Determinants of Smallholder Participation in Common Bean Markets in Uganda and Mozambique.

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Title: Determinants of Smallholder Participation in Common Bean Markets in Uganda and Mozambique

Problem: Smallholder farmers in Africa have diverse resource endowments and face different risk issues and constraints in market participation. Understanding farmer access and participation in bean markets is crucial for production improvements, increased productivity, and food security in Uganda and Mozambique.

Key Findings: Interviews with farmers in Uganda ($n = 302$) and Mozambique ($n = 305$) have revealed constraints to market participation that discourage production of marketable surpluses. These include poor quality of seed; post-harvest storage challenges; non-competitive farm gate prices; poor or irregular infrastructure; high transportation costs; faulty weighing scales; and imperfect information in a highly risky environment. Our findings indicate that these constraints will need to be addressed individually and collectively by farmers, and through support from government and non-governmental organizations. Our research is identifying and prioritizing factors that are within the realm of farmers. For example, to provide and stimulate adoption and use of improved bean production and soil fertility management practices and technologies, and thus, marketing in Uganda, Bean Innovation Platforms are being developed and supported.

Overall significance of findings and future research: To address low smallholder participation in the bean market, our focus is on identifying determinants of market participation and ways to alleviate constraints. Identifying measures that will improve smallholder farmers' participation and integration into markets can stimulate investments for bean production and improved soil fertility management practices for sustainability.

Paper Number: 1109 (Poster Number: 53)

Harnessing the Middle of the Chain: Engaging Traders to Improve Bean Value Chain Productivity.

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In Uganda, 70% of people engage in agriculture activities (FAOSTAT 2014). Beans are an important crop, but smallholder productivity has stagnated due to lack of improved inputs and weak extension services (Brookings 2013). The Feed the Future Uganda Commodity Production and Marketing Activity hypothesized that it could engage private trader networks to fill the extension gap and provide improved bean seed, improving smallholder productivity.

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By engaging self-selecting, middle-of-the-value-chain traders and their village agent (VA) networks, the Activity is helping bean farmers to increase productivity. The Activity trains traders and their VAs, who work with trusted farmers to promote improved technologies, bean varieties, and practices to stimulate greater demand. Input demand drives sales to VAs, and resulting productivity gains increase farmer sales, creating a positive feedback loop. For beans, in the first two years the Activity has trained 23 traders and their 185 VAs, leading to 25,676 implicated farmers and over \$11 million in new farm gate sales. The Activity helped improved bean seed growers sign export contracts worth \$4.7 million, and ICT solutions have allowed traders to provide customized financial, extension, and market services to additional farmers. The initial success reflects significant buy-in to the Activity's hypothesis, and its potential for replication in legume value chains elsewhere. The Activity has learned important lessons like the willingness to drop support for non-compliant VAs. The Activity will continue to adapt in subsequent years as it tests improved ICT-enabled extension services to reach smallholder farmers dispersed across wide geographic areas with heterogeneous constraints.

Paper Number: 1110 (Poster Number: 54)

Major Factors Influencing the Uptake of Index-Based Insurance Products in Sub-Sahara Africa.

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Innovative risk mitigation and adaptation measures need to be implemented in order to increase agricultural production in the face of climate change and variability. The lack of access to formal risk management mechanisms force farmers to self-insure against environmental disasters whilst informal risk management methods often diminish agricultural productivity and provide limited coverage. Agricultural insurance products have demonstrated their ability to cope with income losses due to environmental stresses and market prices variability. However, insurance products in general face low rates of adoption in Sub-Sahara Africa. Based on a comprehensive review of available literature, this paper investigates the potential factors that influencing the uptake of index-based insurance products in developing countries. Limiting review on studies on index insurance products conducted in Sub-Sahara Africa, the paper examines (i) the insurance products availed to farmers, (ii) factors that influencing uptake of insurance products and (iii) major challenges limiting farmers accessing to insurance products. This review reveals that area yield index insurance, index based crop insurance and index based livestock insurance have been successfully piloted in SSA region. Insurance adoption was found positively correlated with on-farm income, educational level and savings; and negatively correlated with age of farmers, land tenure and farm size. Public-private partnerships, farmer-driven product design and government subsidies were found as positive catalysts for insurance products scalability. Challenges limiting uptake of these products include basis risk, data availability, integrity of weather station, capacity building and education of stakeholders, limited product options and lack of innovation for local adaptation and scalability.

Paper Number: 1111 (Poster Number: 55)

Opportunities for Sustainable Legume Business Development: An Experience from the Public-Private Partnership Progresses in South Eastern Ethiopia.

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Chickpea is widely grown food grain legume in rotation with cereals and is an important source of food and income. The chickpea value chain comprise of different actors at different functional levels. Evidence indicates that it is characterized by weak chain coordination leading to poor production performances and market information asymmetry. An N2Africa project facilitated Public-Private Partnership brought together a private commercial farm, public agricultural research, a private chickpea exporting and an inoculant supplying company. Coordination and joint planning greatly improved chickpea technology dissemination and the business relationships between out-grower farmers, the nucleus farm and the input and output supply companies. The nucleus farm, Balegreen Spice and Grain Development, pioneered mechanizing chickpea farming and breaking a long cereal mono-cropping practice. They are involved in seed multiplication, grain production both in its own and through small holder out-growers, extension services, fertilizer and inoculant supply, grain bulking and delivery to the exporting company. The contribution from Oromia Agricultural Research Institute is technical support and Monitoring and Evaluation whereas basic seed supply and grain sourcing is attributed to Agricultural Commodity Supplies Ethiopia. Menagesha Biotech Industry is committed to producing and supply inoculants to the out-growers and other farm communities through the nucleus farm. Experience from this partnership model shows there is need for a built-in appropriate progress tracking and feedback mechanism and a coordinated effort of legume value chain actors is crucial to sustain technology dissemination and for a win-win business relationships at the different levels of the chickpea value chain.

Paper Number: 1112 (Poster Number: 56)

Who Consume More Pulses? an Empirical Investigation of Consumers in Tanzania.

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Studies that have comprehensively assessed and delineated the consumption of pulses across consumers' profile have generally been rare. This article goes beyond identification of factors underlying the consumption in Tanzania to pin-pointing consumer groups that differ in terms of frequencies and levels of consumption. This information is important for promoters of legumes and firms contemplating to venture into businesses involving legumes. Differences in consumption between groups of households' heads classified according to age, education, adult equivalent and food expenditure were tested (Kruskal-Wallis). Mann-Whitney was used to test for differences between paired groups of these variables and to compare the consumption between male and female, married and single households' heads and those in rural vis-à-vis urban. Results show that male heads consume more pulses and more frequently than female heads. Heads residing in rural consume more pulses than those in urban. Heads with primary education consume pulses more frequently but in smaller portions than those without this education whereas those with secondary education consumed less than the former. Middle expenditure group consume more than lowest expenditure group. Households with few adults consume fewer pulses and than household with more adults. Heads with 16-30 years consume fewer pulses than others. The amount consumed increase with age up to 45 years when it falls. The implication of these findings is that market development should target heads who are young and old, female, more educated, with higher incomes and residing in urban areas. Future research should focus on attributes of pulses that appeal to these consumers.

Paper Number: 1113 (Poster Number: 57)

The Effect of Ecowas Common External Tariff on Agro-Processing in Nigeria.

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This paper measures the possible impact of the implementation of the ECOWAS Common External (CET) Tariff on Nigeria. It made use of the World Integrated Trade Solution (WITS) Single Market Partial Equilibrium Modelling Tool (SMART) to simulate three scenarios: i) applying a zero tariff rate on all products for ECOWAS partners ii) complete elimination of existing import tariffs on all European Union members in addition to ECOWAS partners iii) full implementation of the CET on all agricultural and agro-processing products while excluding the levies. The paper indicates that implementing the CET would have both negative and positive effects on Nigeria depending on the initial level of applied Most Favoured Nation (MFN) duty rates. Trade creation will increase if MFN rates are replaced with scheduled rates, but the moment import levies are excluded the effect becomes negative. This loss can be compensated for as the CET is expected to reduce the tendency of informal trade. The scenario including the removal of import levies would lead to additional imports of non-excluded products. As for the levied products, there was no trade creation. Conversely, if the levied products are excluded under scenario iii) full CET implementation on all agricultural and agro-processing products would lead to adverse effect on the milk and cream nes sweetened that is imported from Ghana. Overall, the implementation of all three scenarios would generate more trade in most of the agricultural and agro-processing products. The implementation of the CET is a prospect for agro-processing in Nigeria. In other words, trade is facilitated at the Nigerian and ECOWAS borders as informal trade is reduced to its barest minimum. This paper also indicated excluded products and the effect in terms of trade facilitation. This is because a change in trade creation results from excluding products that attract special levies. The new duty rates were set to zero excluding those products which attract special levies. The tariff rates of these excluded products remained at the initial levels despite the equi-proportionate tariff cut that was introduced for all products. The trade diversion effects are more noticeable when the values of elasticity are high rather than low. The effects of trade creation on the other hand are more obvious at low elasticity values instead of high elasticity.

Paper Number: 1114 (Poster Number: 58)

Assessment of the IMPACT of Improved Cowpea Technology on Income of Women Farmers in Borno State, Nigeria.

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ABSTRACT

The study examined the impact of improved cowpea technology on the income of women farmers in Southern Borno State, Nigeria. The specific objectives were to describe the socio-economic characteristics of women cowpea farmers in the study area; identify the changes in income as a result of using improved cowpea seeds by the respondents; and identify the constraints associated with the use of improved cowpea. Both primary and secondary data were used for the study. The primary data were collected by use of structured questionnaires administered to 240 participants and 60 non-participants to give a total of 300 respondents who were selected using a random sampling technique. Respondents were mostly within the age group of 31-40 years.

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Majority are married (68% participants and 75% non-participants), a large proportion (38% participants and 35% non-participants) have household of 6-8 people. An average of 66% participants and 62% non-participants were educated with mean farm sizes of 1.2 and 0.8 hectares respectively. Findings from Double Difference estimates indicated that the income of the participants increased by N143, 495.20 (\$724.72) which was higher than that of the non participants which increased by N58, 500.00 (\$295.45). This indicates that there was a positive impact on income as a result of using the improved cowpea varieties. The improved cowpea farmers were constrained by diseases and pests, high cost of labour and inadequate access to markets. It is recommended that the farmers be enlightened about post harvest handling of crops and be encouraged to adopt the improved storage technologies. They should also be encouraged to form cooperative associations to facilitate marketing of their output so that they can sell more and earn more income.

Paper Number: 1115 (Poster Number: 59)

Assessment of Farmer Demand Along the Soybean Value Chains and Their Related Supply Strategies in Mozambique.

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Erratic smallholder farmer demand for certified legume seeds, fertilizers, inoculants and herbicides are cited as major constraints for developing profitable input supply chains. Input firms often fail to map demand, which hampers their capacity to build efficient input supply chains. Our recent surveys in Mozambique on farmer willingness and commitment to purchase certified seeds, P-fertilizers, inoculants and herbicides for soybean found that farmers perceive certified seeds of improved varieties as the primary input for good yields, followed by inoculants. Fertilizer use was seen to be of secondary importance. Preferred varieties from private firms were not locally available and most farmers sourced seeds as grain either through farmer's associations or local markets. 25% of the farmers said that if improved varieties were made available, they were on average willing to buy 90 kg of seeds at \$1.25 per kg. 59% of the farmers expressed their willingness to purchase five packets of inoculants priced at \$3.75 per 100 grams. Herbicides were favored by 30% of the farmers. Only 12% of the farmers were willing to buy NPK at \$31 per 50 kg bag, similar to actual usage in the previous season. Our findings and subsequent discussions with different stakeholders in the supply chain have resulted in meaningful partnerships and actions. For instance Seed Co, one of the leading Pan-African firms in soybean seed R&D commended the findings and plans to invest in soybean seed distribution and inoculum through an extensive network of input suppliers.

Paper Number: 1116 (Poster Number: 60)

Price and Quality of Legumes in Fodder Markets of Northern Nigeria.

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Legume fodders play a significant role in the nutrition of livestock throughout the Sudano-Sahelian zone of Africa. Quality of these fodders should be an important consideration of their value; however, other research in West Africa has reported limited relation between quality and market price. We, therefore, collected data to evaluate factors that might determine legume fodder prices in northern Nigeria. Prices were recorded for groundnut (GH) and cowpea haulms (CH) at monthly intervals from five fodder markets in Northern Nigeria from January 2009 to October 2010. CH was only available in one market during the wet season, whereas GH was available throughout the year and was sold in bundles of small medium and large. Small bundles of GH price varied from Naira 450 to 1400 with an average 616 while those for CH were lower, varying from 110 to 160 with an average of 140. Apparent higher quality of the GH was observed through visual grading primarily as 'green and leafy' compared to 'green and stemmy' for CH. Haulm samples were analyzed for nutritional quality by near infrared spectrophotometry. GH contained significantly lesser ($P < 0.01$) NDF and tended to contain greater ($P < 0.10$) N (49.3 and 2.4 g/kg DM, respectively) than CH (59.9 and 1.9 g/kg DM, respectively). This was reflected in the higher prices for GH compared to CH. Contrary to previous reports, we observed GH to have higher quality than CH and this affected relative prices of those fodders in markets of northern Nigeria.

Paper Number: 1117 (Poster Number: 61)

Opportunities for Youth Employment Along the Cowpea Value Chain in Zambia.

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Cowpea (*Vigna unguiculata* (L) Walp) is a strategic legume as it supports food and income security for poor farm families. Traditionally cowpea is considered a women's crop in southern Africa and youth participation in the cowpea-value-chain can reduce unemployment. Currently, the involvement of youth in agriculture has dwindled largely due labour intensive and time consuming agricultural production practices and processing methods in use. Youth also face other challenges including lack of specialized skills, capital to start projects, access to land and stiff competition for opportunities from adults. However, the cowpea value chain offers a range of entry points for youths to participate gainfully in agriculture and agribusiness enterprises. We describe a model of engaging youth in the cowpea value chain in which service provision, market facilitation and private sector linkages can lead to agribusiness development. Youth can engage in formal business enterprises along the cowpea value chain and avoid prohibitive requirements for accessing capital for businesses. The involvement of off-taker and private sector players is an important step in the facilitation of skills development, communal marketing and provision of market guarantee and stable pricing. Development of youth friendly financial products can also increase the success rate of youth projects. We advance sustainable models that support youth engagement in agriculture for improved incomes and job creation.

Paper Number: 1118 (Poster Number: 62)

Effect of Access and Control of Productive Resources and Incomes on Bean Production in Selected Bean Production Corridors of Kenya.

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Gender related constraints reflect gender inequalities in access to resources and development opportunities. Access to productive assets is a major issue in the gender empowerment discourse. Despite the significant roles women play in agriculture and food security in many developing countries, they continue to have a poorer command over a range of productive resources, including education, land, information, and financial resources. Data collected from 412 households in the major bean corridors of Kenya were used to explain the importance of access to productive resources and income use in determining the quantity of beans produced by households. We found that the gender of the household head is correlated with bean production, with female headed households producing less beans than the male headed households ($p=0.014$). With regards to access and control of productive resources, households with more agricultural incomes and those that put a larger proportion of their land to agriculture produced more beans ($p=0.026$; $p=0.000$ respectively). When decision making on the use of income from bean sales was considered, households where the female spouse made decisions produced less beans compared to those that had the male household head being the main decision maker ($p=0.011$). We conclude that the control of productive assets are important in determining the quantity of beans produced at household level. There is need therefore to come up with interventions which will benefit all the households but are targeted to the needs of the male and female headed households.

Paper Number: 1119 (Poster Number: 63)

The Integration of Cowpeas and Soybeans for Improved Nutrition, Health and Gender Empowerment in Zambia and Malawi.

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The integration of legumes such as cowpeas and soybeans into the farming system that is dominated by maize is very minimal due in part to limited access to improved varieties and limited information on cultivar selection and on management practices such as the optimum time to plant. The advantages of growing legumes such as cowpeas and soybeans include among others, income, good source of protein for human and animal nutrition, nitrogen fixation and improvement of soil structure. Despite these advantages, some farmers are excluded from participating in many development efforts due to their health status. Several studies have examined the impact of integrating legumes in maize-based system on food and nutrition security. However, little is reported in literature on the impact of legume integration on gender empowerment and equity especially among households affected by HIV and AIDS. The study explores the social and economic impact of an agricultural for Health and Nutrition project that targeted households affected by HIV and AIDs in Malawi, Zambia Mozambique and Swaziland. The research comprised qualitative interviews and focus group discussions. Results obtained indicate that integrating cowpeas and soybeans with emphasis on improved varieties, agronomic practices and postharvest technologies promoted socio-inclusion and empowerment among small holder farmers affected by HIV/AIDS.

Paper Number: 1120 (Poster Number: 64)

On-Farm Perception of Improved Bean Varieties Among Vulnerable Women Group in Eastern, Zambia.

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Abstract

Title: On-farm Bean Improved Varieties- a tool to empower Vulnerable Women Group in Rural, Zambia

Rural women in Zambia are tasked with not only preparing food for the family, but ensuring that the family especially children access adequate and nutritious food. Rural women lack the knowledge and skills and access to new research technology in the process of agriculture production that strengthens their ability to ensure that respective households and access adequate and nutritious food. Access to proteins in a rural setting where carbohydrate is the predominant staple like maize is a challenge for most vulnerable rural women in Zambia and most of Southern African countries. The maize staple is consumed with accompanying relish such as meat, fish and other sources of proteins for a health meal. To afford meat and fish as source of protein remains a challenge for households that earn less than half US\$/day. During 2007 season the Zambia Agriculture Research Institute based at Msekera Research station in partnership with CIAT (International Centre for Bean Research based in Lilongwe, Malawi) and PLAN Zambia introduced four newly developed improved bean varieties for farmers assessment in Chadiza district of eastern Zambia. Among the groups that was targeted in was vulnerable women group called "Chisomo" womens' group consisting of 12 members. After three seasons of testing the four new improved beans of Chambeshi, Lukupa, Lyambai, Kapisha, Kabale varieties the Chisomo women group not only appreciated the yield benefits of the new bean varieties as a source of income, but more importantly articulated the nutrition benefits of bean in their diet and as source of income. From consuming beans only once in six months they started consuming beans 3 times a week in their families. On the other hand women demanded to expand the bean production of improved varieties from research to increase their disposable income. Although, there was no study to follow up on the improved health improved of households and increase in their income there was a visible change in their health status, income and the impact of new bean technology coming from agriculture research. A focussed and formulated study of this particular group holds important research findings of benefits of research technology related to health beans and increased incomes for vulnerable women.

Title: On-farm Bean Improved Varieties- a tool to empower Vulnerable Women Group in Rural, Zambia

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Paper Number: 1121 (Poster Number: 65)

Gendered Nature of Bean Marketing in Central Uganda.

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In central Uganda, beans have been traditionally produced by women mainly for household consumption. Presently, the crop has evolved from being majorly a food crop to a commercial one. This change in use attracts intervention by men in the marketing area. This paper aimed at establishing the factors that influence involvement of men and women in marketing of beans. Using part of data from a base line survey that was conducted in central Uganda where 659 households were purposively selected, study findings revealed that men are more engaged in marketing compared to women. Women engagement stood at 44.7% compared to 64.7% for men among the interviewed households. This is attributed to factors such as bargaining capability, access to market information, crop ownership, ability to ride and travelling long distance to the market socially ascribed to men. Women are further limited by the routine occupation of performing household chores. Additionally, the study showed the reasons for differences in gendered market engagement which can be summarized under three major categories; social norms, crop ownership and gender specific differences. While this was revealed, it's important to critically further understand why men continue to dominate the role of marketing even when the crop is produced by the woman or even both. Developing scenarios of what is likely to transpire as the crop is commercialized is key in providing guidance in designing of suitable interventions for equitable benefits for both men and women.

Key words: Engagement, Women and Men, Marketing, and social norms

Paper Number: 1122 (Poster Number: 66)

Factors Affecting the Diffusion of the Innovations By Gender in Cowpea Value Chains in West Africa.

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Cowpea value chain is a high potential for food security and income growth of women and youth. Despite efforts to the scaling out of the innovations in the cowpea grain value chain, the chain is facing by several constraints which are mainly related to gender in West African countries. Major constraints are mainly the low accessibility to market inputs and products, the lack of information and the low rate of literacy among women and the youth. Gender studies and agricultural policies showed the integration of women and young in cowpea value chains provide efficient. The overall objective aim to analyse the factors affecting the scaling out of innovations according to gender analysis in Ghana, Mali, Nigeria and Senegal. The main hypotheses are women and young people control the resources in the level of production (ii) women and young people have access to resources in the commercialization and production level. The Havard and Moser analytical framework and Logit model are used for the collection of data. The results revealed that women and youth have access to resources related to marketing and production. The development policies should particularly work towards the removal of all constraints and to improve the access and control of rural women about resources and opportunities in order to make more efficient cowpea value chains. For future research, the capacity building through the training and awareness on the new technologies in the transformation would be an asset for women and youth in these countries.

Key words: Gender, Innovation, cowpea

Paper Number: 1123 (Poster Number: 67)

Gender Roles and Constraints in Cowpea and Groundnut Cropping; A Case from Niger.

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The Problem:

Rain-fed agriculture and agro-pastoralism systems constitute the main sources of both food and incomes of poor farmers of the West African Sahel countries such as Niger which faces the vagaries of climate change that effect environment, economic, and social habits of exposed populations. Niger is the poorest country of the world where poverty affects rural areas more than urban areas, and is more pronounced among the female population. Women are generally considered to be at the lowest rung of the poverty ladder as they represent 70% of people living in poverty; also 96% of households headed by women are considered poor. Ensuring food security for small-scale, vulnerable farmers is becoming more and more challenging. Even though a good number of improved varieties of cereals and legumes have been released for different agro ecologies of Niger by research institutions. Yet the majority of farmers still prefer their own saved seeds. Women are main custodian of local seeds. And whenever the word farmers is used it is always considered as men. And yet in Niger, women represents 36% of the economically active population in agriculture (FAO, 2013). This necessitates to understand what are women and men preferences in the crops they cultivate, the varieties they chose and the constraints faced by them to better manage risks and improve their livelihoods by diversifying the farming system and rural income. Against such a backdrop thus the specific objective of the study were:

1. An integrated analysis of social, economic and environmental dynamics considering the crop-livestock system.
2. An analysis of livestock biodiversity and main local crops including preferences, practices and producers' knowledge by taking gender into account.
3. An analysis of the performance of the favorite main crops at farm level and at the analytical laboratory along with ex-situ conservation.
4. A participatory analysis of local constraints to the production system, strengths and opportunities to improve the resilience of crops and livestock in local agro-ecosystems.

The present paper reports the findings of gender roles, constraints and preferences in food- feed crops with special emphasis on cowpea and groundnuts.

Methodology:

The survey was conducted in purposive selected Milli and Gourjia villages of Niger. The criteria of selection was 0.35 aridity index (AI), 70 habitation km² population density (PD). The methodology utilized various mix -methods, utilizing secondary sources of information, participatory qualitative tools of socio-economic gender analysis (SEGA) approach and other tools like such rank based quotient, four square analysis. The survey was carried from July to September 2015. The present paper indicate the findings of gender preferences in cowpea and groundnut varieties

Key Findings and their Implications:

Rank bank quotient revealed the constraint faced by men and women farmers in crop-livestock system: constraints by women in Milli were: low yield (63.89), insufficient rainfall (61.11) and crop diseases (50) while men reported: low rainfall (81), no access to fertilizer (57.14) and crop diseases (37). Gourjia women farmers main: issues were lack of feeding resources for animals (80.95), while men farmers reported low rainfall (63.5) and less access to inputs (50.5). The main inspect pest faced by the farmers on cowpea and groundnuts were aphids, thrips, pod borer etc. and rosette was most common disease in groundnut.

This contributed to low agricultural productivity coupled with lack of resources, inputs like seed, fertilizer and pesticides, and lack of water conservation structures during rainy season. Seasonal calendars from Milli and Gourjia revealed that gender agricultural practices were rainfed (May- September) and irrigated farming (October to April) and livestock fattening (January-December) but women did not graze animals. Cowpea and groundnut crop were sown by men and women during June for rainfed, while October for irrigated farming. Daily activity clock of young women in Gourjia and Milli indicated that they worked more (14-16hours) than young man (10-12hours) towards agriculture, livestock, market, household activities. Women were more involved in the hard work and less involved in decision-making. Four square analysis tool assisted in making an inventory of crops and their varieties and their importance and the number of households using the variety. In Gourjia the two most available and important cowpea varieties were: Man Hutilla and Jan wake. In case of Milli village – Man hutilla, Dan doramawa, Dan adamu, Dan bauchi, Dan burkina were the cowpea varieties sown. In Gourjia crop matrix tool revealed that Mai Hutilla variety was number one cowpea variety by men and women. This variety was considered best for both rainfed and irrigated farming for both for grain and forage production. Men gave 2nd rank to IT90 variety because of its high market value, while women preferred Jan Wake because of its taste. In the case of village Milli: men preferred Dan Doramawa for its grain yield than Dan Bauchi preferred by women for its forage yield. In case of Gourjia and Milli, groundnut El Masara variety was largely preferred for grain and fodder production even if it got a longer cycle duration. Groundnut seed was valued more than the grounder fodder, while in case of cowpea, cowpea fodder and husk were equally important like cowpea seed. The local varieties offered only medium but reliable yields, seeds were accessible, under variable climatic conditions and without the use of agro-chemicals. Improved varieties were more demanding with respect to climate, pest requirements. Yields in marginal environments where improved varieties are not adapted can be improved.

Conclusion:

There is a need to develop climate smart varieties requiring low input, disease and drought resistance, accessible, adapting to local taste. Breeding institutions should consider the gendered distribution of preference and needs of the special traits and integrate them into selection scheme in order to develop relevant variations of women and men.

Paper Number: 1124 (Poster Number: 68)

Intra-Household Participation in Bean Production; The Case of Central Uganda.

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Women undertake a number of bean production activities especially at the production node of the value chain. This over burdens them given that they have to undertake other roles. Engendered activities at the different nodes of the value chain would give relief to the over burdened women. A study to analyze the intensity of participation of men and women in different production activities was implemented in ten districts of central Uganda. Using data from 660 bean farming households purposively selected, data analysis was done using chi-square and T-test statistics. Participation focused on site selection, Bush clearing, Land opening, final ploughing, planting and weeding. Findings indicated 70 percent of female respondents took part in these activities. Similarly, nearly 70 percent of male respondents reported participating in the same activities. This is contrary to the quote that beans are a women's crop. Females stood out as the major players in harvesting and post-harvest management with 60-80 percent of the sampled households. Males reported high involvement in 30 to less than 50 percent of the sampled households. Results also indicated males were intensively involved in transportation from the garden to the drying yard. This was reported by 60 percent males of the households interviewed. The findings inform the current status of gender participation in the bean value chain and points out some key gender disparities of chosen parameters that deter women empowerment and inclusiveness in production support services. Further research can be conducted to unearth the desired turning point for equal participation of women and men.

Key words: Intensity of participation, gender disparity, bean value chain

Paper Number: 1125 (Poster Number: 69)

A Critique on Research Prioritisation on New Bean Markets and the Youth in Malawi: Transforming the Region.

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Livelihoods of many young Malawian bean farmers are constrained by poor access to input and output markets. Despite government interventions and research, the needs of young farmers have not been fully addressed. A literature synthesis was employed in this study to document the status of research on challenges and opportunities of bean markets in Malawi and role of the youth in those markets. Secondary information on bean sub-sector analyses, regulatory frameworks, and government reports on bean markets, prices, production and consumption, related policies for Malawi, export and import data was also reviewed. The results indicated that much effort has been put in research for development in improving bean varieties and bean production systems.

However this has been overshadowed by poor sequencing of agricultural policy reforms. In addition, bean markets are largely affected by high transaction costs. Similarly, weak government support on marketing and trade facilitation impedes progress in food market development. The adoption of structural adjustment and agricultural market reform poses a great opportunity for young bean farmers to sell their beans above export parity price. Malawi being a member of COMESA, SADC, AGOA, EBA and the WTO is an opportunity for many young bean traders to compete in international markets. However, these opportunities are underutilized due to lack of information on their existence. The study therefore recommends a shift in research priorities by putting forward workable methods on how the youth can be integrated within research activities on scientific technologies, to utilize the bean market opportunities in the region.

Paper Number: 1126 (Poster Number: 70)

Ascertaining the Breeding System of African Yam Bean: A Primary Process to Underutilized Legume Improvement.

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Abstract

The notable inherent nutritional potential in African yam bean (*Sphenostylis stenocarpa* (Hochst. ex A. Rich.) Harms) is a platform for the need of its genetic improvement. However, breeding program will not be successful without a good knowledge of the breeding system of the species of interest. Four accessions of African yam bean (AYB) collected from the Genetic Resources Centre of the International Institute of Tropical Agriculture (IITA), Ibadan were grown out in a fifteen plants/accession row on a field at IITA, Ibadan (7.50N, 3.90E). Five pollination mechanisms were investigated as treatments on each of the four accessions. Data generated on fruit and seed set percentage by the five treatments were subjected to descriptive statistics. Fruit and seed were set in four treatments: plants left to open-pollination (A), plants isolated with fine net mesh (B), artificially selfed flowers (C) and inter-varietal cross-pollination (D). Emasculated flowers which were not pollinated (treatment E) produced neither fruit nor seed. Treatment A differed significantly ($P < 0.05$) from B, likewise C and D. Fruit set percentage was higher in A (19.7-21.2) than B (18.3-18.7). Higher pollination/fertilization success (46.5%) was obtained in C compared to 32.3% in D. More seeds (88.6%) were set by self-pollination. The four accessions had a mean selfing rate of 89.8% and an outcrossing rate of 10.17%. The observed 1:9 allogamy/autogamy in this study could form the basis for the breeding strategy development for genetic improvement of AYB.

Keywords: African yam bean, emasculation, pollination mechanisms, breeding system, selfing rate, outcrossing rate

Paper Number: 1127 (Poster Number: 71)

Introgression of Striga Resistant Gene into Farmers' preferred Cowpea Varieties in Niger.

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Striga gesnerioides (Wild.) Vatke, a parasitic flowering plant is one of the main biotic sources of stresses that challenge cowpea production in drought-prone areas. At least seven races of *S. gesnerioides* with differential virulence on cowpea cultivars have been identified in West and Central Africa. This renders breeding effort very delicate. However the identification of molecular markers tightly linked to the various *Striga* races opened the way to the marker assisted selection for the resistance to *S. gesnerioides* in cowpea. There was a need to demonstrate the feasibility of marker technology in developing resistant cowpea varieties. The objective of this study was to introgress one *Striga* resistant gene (*Rsg1*) into susceptible and adapted cowpea genotypes. Marker assisted backcrossing (MABC) was used to transfer *Rsg1* *Striga* resistant gene from the breeding line IT93K-693-2 into three farmers' preferred varieties; IT90K-372-1-2, KVx30-309-6G and TN5-78. The microsatellite marker SSR1 was used to tract and introgress the resistant gene *Rsg1* in the varieties IT90K-372-1-2 and TN5-78. The marker which produced a single band in resistant lines and amplified a 150 bp fragment was validated with the parents and the subsequent F₁, F₂ and BC₁F₁ populations. Ten promising lines with the resistant marker were selected in BC₂F₃, BC₃F₃ and F₆ populations derived from the crosses IT90K-372-1-2 x IT93K-693-2 and TN5-78 x IT93K-693-2. Further evaluations and improvement of these genotypes will probably accelerate the release of varieties combining farmers' preferred traits with stable resistance to *Striga*.

Paper Number: 1128 (Poster Number: 72)

Evaluation of Bean Varieties Under Different Agro-Ecologies in a Farmer Participatory Variety Selection (Fpvs in North Rift Region, Kenya).

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Evaluation of Bean varieties under different agro-ecologies in a Farmer Participatory variety selection (FPVS in North Rift region, Kenya Kwambai, T. K1., Barkutwo, J1., Kimurto P.K2, Komen, S3. Karanja, D. R4., Macharia, J4., Otsyula, R5., Micheni A6 and Towett B.K2

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Abstract

Although scientist release varieties regularly, farmers have limited exposure particularly in the North Rift Counties of Kenya.

The study was aimed promoting high yielding newly released bean varieties in varied agro-ezones (Elgeiyo Marakwet, Uasin Gishu and Trans Nzoia) of Kenya and enhancing seed availability for increased food security, nutrition and incomes. On-farm evaluation was conducted using 12 bean varieties including Chelalang, KAT RM-01, Embean14, Tasha, Embean118, KK8 and KK15 and two local check (GLP585 and 292-Wairimu) in a farmer participatory. Farmer Participatory variety selections (FPVS) by both men and women. Mean yield ranged from 1.1-2.21 t ha⁻¹ in the five multi-locations. The variety Embean14 showed significant ($P<0.05$) high grain yield (2.08 t ha⁻¹) across five locations, but it was not significantly different from other Chelalang, Ciankui, KATX56, KK8, Embean 118 and KAT RM-01. Iten and Anin sites in Elgeiyo Marakwet County were the best high yielding sites (2.13-2.21 t ha⁻¹) followed by Kipsomba (Uasin Gishu) (1.44 t ha⁻¹) while Endebbes (Trans Nzoia) was the worst performing site. FPVS results showed that the choice of most preferred varieties varied widely between the two sites. Market and eating attributes were key determinants for selection of a variety. Overall, Chelalang was ranked as the best by both gender followed by Tasha and Eambean118. Male gender strongly preferred KAT RM-01 followed by Embean14, but they strongly rejected KK15 and GLP292. On-farm FVPS proved very successful in eliciting feedback and increasing awareness of newly improved varieties hence should be integrated in variety release and promotion procedures.

Key words: Common bean, varieties, on-farm evaluation, FPVS, North Rift Kenya

Paper Number: 1129 (Poster Number: 73)

GWAS for Yield Component QTL Under Drought in a Common Bean MAGIC Population, and Molecular Marker Development Using Sequencing Data.

bodo raatz, carlos jara, juanita gil, paulo izquierdo, Juan David Lobaton, jorge duitama and Steve bebe, CIAT*

Common bean production is affected by abiotic stresses like drought and many biotic constraints. Breeding for improved varieties is a sustainable method to improve yield stability. New genomic technologies need to be implemented to improve genetic studies and molecular breeding efficiency, like modern genetic population designs high throughput sequencing data derived molecular markers. A MAGIC (multi parental advanced generation intercross) population was developed from 8 Mesoamerican breeding lines, Genotyping by Sequencing (GBS) produced 30k SNP markers. Association mapping with phenotypic data from two drought trials revealed several regions associated with yield, flowering time, days to maturity, seed weight and other yield components. Haplotype blocks of several combined markers show similar trait associations, consistent over both seasons. Re-sequencing of several common bean genotypes produced a large amount of genomic resources that can be applied for molecular breeding. Whole genome sequencing (WGS) data from ALS resistant genotypes G5686 and G10474 produced a large quantity of genotype specific SNPs. Three different types of SNP based markers tagging ALS resistance were designed based on these SNPs and genotyping of a common bean panel shows that these markers are superior in specificity and can be used to tag valuable alleles in marker assisted selection. Provided data shows that MAGIC populations can be applied to determine marker-trait associations and that SNP markers selected from large sequencing data sets can be superior to previously used markers. These new technologies will improve genetic studies and marker development, to accelerate development of more resilient germplasm.

Paper Number: 1130 (Poster Number: 74)

Variations in Food-Feed Traits in a Core Collection of Chickpeas.

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Background The demand for livestock fodder increases the value of many cereal and legumes crop residues relative to grain and pod prices. Recently chickpea haulms have become a marketable commodity in India and Ethiopia. Chickpea improvement might need to react to these demands and chickpea haulm quantity and fodder quality and possible trade-offs between these and grain yield are key variables to consider. These relationships were examined in 280 chickpeas of the ICRISAT core collection grown under control (C) and water restricted (R) conditions in India. Key findings Significant ($P < 0.001$; $R: r = -0.62$, $P < 0.001$) and positively to haulm yield (C: $r = 0.14$, $P = 0.017$; R: $r = 0.54$, $P < 0.03$; R: $r = -0.50$, $P < 0.001$) and positively to haulm yield (C: $r = 0.18$, $P = 0.002$; R: $r = 0.43$, P

Paper Number: 1131 (Poster Number: 75)

Conservation and Utilisation of Cowpea Genetic Resources.

Michael Abberton*¹, Ousmane Boukar², Christian Fatokun², Olaniyi Ajewole Oyatomi¹ and Lava Kumar¹, (1) IITA, (2) International Institute of Tropical Agriculture

Abstract

Statement of problem

Cowpea (*Vigna unguiculata*) has its origin in sub-Saharan Africa and has a major centre diversity in West Africa where it is a very important crop of the savannah regions. The Genetic Resources Centre (GRC) of IITA conserves more than 15000 accessions of cowpea from many parts of Africa. Enhancing the utilisation of this germplasm is a key challenge in developing cowpea varieties to contribute to food security in the face of climate change.

Key findings

Morphological and molecular tools have been used to develop core and mini core collections which have been extensively used by breeders in IITA and beyond. In collaboration with the Germplasm Health Unit (GHU), IITA we are carrying out an intensive program of indexing and regeneration of cowpea accessions to ensure that they are healthy (including free of virus) and available for distribution. In addition GRC conserves 1500 accessions of 45 species closely related to cowpea. Although there are crossing barriers in some cases, these are important resource for cowpea breeding particularly with respect to tolerance of biotic and abiotic stresses. Both wild relatives and landraces of cowpea have recently been identified with resistance to Striga, a major threat to cowpea through much of its range in West Africa.

Overall significance

Through a combination of approaches the considerable genetic resources available to underpinning cowpea improvement are being deployed to the benefit of smallholder farmers across West Africa.

Paper Number: 1132 (Poster Number: 76)

Deploying Photosynq to Enhance Local Pigeonpea Breeding Programs in Malawi.

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In sub-Saharan Africa, plant breeders often lack the infrastructure needed to take advantage of new, high-throughput phenotyping tools. Thus, their ability to screen for high performing phenotypes that are well-adapted to sub-Saharan Africa's agroecological conditions is severely limited. Inexpensive and easy-to-use tools are needed to improve plant breeding programs in sub-Saharan Africa.

PhotosynQ, a combination of the hand-held MultispeQ device and the PhotosynQ web-based platform (www.photosynq.org), is a new, inexpensive, and easy-to-use plant phenotyping tool. PhotosynQ was deployed on a pigeonpea breeding trial at Chitedze Research Station in Malawi. Ten locally crossed pigeonpea lines were evaluated for their yield and photosynthetic responses to local agroecological conditions. Photosynthesis data as measured by PhotosynQ was relative chlorophyll content (SPAD), efficiency of photosystem II (Φ_{II}), linear electron flux (LEF), and an estimate of non-photochemical quenching (NPQt). PhotosynQ data was able to identify phenotypical differences in Φ_{II} and SPAD between pigeonpea lines and determine the effect of photosynthetic regulation on crop yield. Higher yielding pigeonpea plots had greater photosynthetic regulation (NPQt) when Φ_{II} decreased compared to lower yielding plots. Furthermore, NPQt was positively correlated with yield while LEF and SPAD were negatively correlated with yield and seed weight, respectively.

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PhotosynQ data can help plant breeders see the unseen plant phenotypical responses to local agroecological conditions and offer early indicators of yield. These benefits can enhance the ability of plant breeders to identify robust phenotypes and lead to the quicker release of better adapted and higher yielding crop cultivars.

Paper Number: 1133 (Poster Number: 77)

Current Status and Prospects of Molecular Breeding of Cowpea in Sub Saharan Africa.

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Cowpea yield is suppressed to the bare minimum as a result of a deluge of biotic and abiotic stresses. The effort to tackle these stresses through genetic improvement has been hampered due to lack or incompatibility of identified sources of resistance. Enriched genomic resources can provide more opportunity to accelerate genetic gain, stack traits, characterize existing diversity in cultivated cowpea and wild relatives, and pyramid favorable gene/alleles in farmer-preferred varieties. In IITA, multi-pronged approach has been launched to characterize diversity of germplasm, to map insect and disease resistance genes, association studies for abiotic stresses and nutritional qualities. A total of 298 mini core cowpea accessions were assayed by 3552 GBS (genotyping by sequencing) SNP markers. Based on Discriminant Analysis of Principal Components (DAPC), assignment of individuals to respective sub-populations was achieved using k-means clustering of PCA-transformed SNP data. Model selection based on the Bayesian Information Criterion (BIC) values showed that the optimal number of clusters is $K = 3$. Draft linkage map was constructed using SNPs in a population segregating for aphid resistance. Likewise genotyping by GBS is underway in a mapping population segregating for cowpea virus diseases. Phenotyping for aphid resistance, virus resistance, drought, and seed micronutrient content is in progress. The outcome of these studies will be thoroughly characterized germplasm, identification of QTL for key biotic, abiotic, and nutritional quality traits. Such genetic and genomic information as well as envisaged genome level gene annotation will provide essential resources for molecular breeding of cowpea with resultant accelerated genetic gain.

Paper Number: 1134 (Poster Number: 78)

Performance of Sheep Fed Chickpea Haulms from Two Widely Grown Cultivars.

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Background Recently chickpea haulms have become a marketable commodity in fodder trading India, however, without price differentiation for fodder quality of haulm as is the case in the trading of sorghum stover and wheat and rice straw. To understand if chickpea haulms, for example from different cultivars, vary insufficiently for fodder markets to merit price premiums, haulms from the two widely grown cultivars JG 11 and ICC 37 were compared as sole feed with sheep. Key findings Protein content ($P = 0.0003$), in vitro digestibility ($P = 0.05$) and metabolizable energy content ($P = 0.08$) were higher in haulms from cultivar JG 11 compared to ICC 37. Intake, nitrogen balance and short term daily weight gain were by 8, 80 and 38% higher ($P < 0.05$) in sheep fed haulms from JG 11. The major difference between the two haulms in laboratory fodder quality traits was in protein content (JG 11: 5.6%; ICC: 4.2%), suggesting protein content to be an important haulm fodder trait. Conclusions The superior performance of sheep fed haulms from JG 11 would justify price premiums for haulms of this cultivar. Extrapolation of data from sorghum stover, wheat and rice straw trading for urban and peri-urban dairy production suggest that haulms from JG 11 could command about 25 to 35% higher prices than haulms from ICCI 37. Fodder traders will be made aware of these differences. Chickpea breeders might consider haulm fodder quality as a value adding trait.

Paper Number: 1135 (Poster Number: 79)

Characterization and Application of the Andean Diversity Panel for the Improvement of Common Bean Productivity in Sub-Saharan Africa.

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Common bean (*Phaseolus vulgaris*) productivity in Sub-Saharan Africa is far below yield potential, while climate change and poor access to inputs are persistent challenges. In addition, the market and human nutrition needs for common bean continue to expand in the African continent, which has the highest rate of human population growth.

The Andean Diversity Panel, of about 500 genotypes from the principal Andean bean production regions worldwide, was created to characterize the phenotypic and genetic diversity of Andean beans and for mining key biotic and abiotic traits constraining production. Genome-wide association studies were completed on trait data including ALS, rust, bacterial blight diseases, and on biological nitrogen fixation and abiotic stress from multiple locations using 31,194 SNPs generated from genotyping-by-sequencing (GBS) with ApeKI. The Phaseolus Improvement Cooperative (PIC) bulk breeding populations were developed from superior ADP lines for specific traits and used for targeted improvement in key common bean production regions in Tanzania, Malawi, and Uganda. Over one thousand lines are now being evaluated in several countries for selection of superior breeding lines for potential release. This effort of the USAID-ARS Feed-the-Future Grain Legumes Project is seeking to increase common bean productivity in Sub-Saharan Africa through the development of germplasm resources, molecular tools, and scientific knowledge. These resources are being shared through application of the Open Data Policy.

Paper Number: 1136 (Poster Number: 80)

Identification of Molecular Markers Linked to Resistance of Cowpea (*Vigna unguiculata* L. Walp.) to Parasitism By *Alectra vogelii*.

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The parasitic weed *Alectra vogelii* (Benth) causes significant yield reduction of cowpea in West and Central Africa. To find a marker that may be linked to the gene conferring resistance to *A. vogelii* in cowpea cultivar B301, an F2 segregating population derived from a cross between a resistant parent B301 and a susceptible parent Banjar was used to establish an *Alectra*-resistant pool and an *Alectra*-susceptible pool. Twenty markers were used in the BSA based on previous research that demonstrated that they were the top polymorphic markers among 140 markers previously screened that were found to show polymorphism between B301 a resistant parent and Banjar a susceptible parent. The twenty markers were used in the BSA performed with DNA bulks of highly resistant and highly susceptible F2 population to identify potential markers that will co-segregate with resistance gene. The markers that showed closest linkage were RB16 obtained from rice bean and CLM0356 obtained from asparagus bean with a genetic distance of 6.5 and 7.5 cM away from the resistance parent, respectively. The utility of the two markers were validated using 150 F2 individual plants for marker segregation and association analysis. The efficiency of the marker was 90.2 and 91.1 % respectively. The analysis of F2 individuals scored for resistance and susceptibility showed that inhibitory gene action governed *A. vogelii* resistance in B301. The Similarity index (SI) revealed that these markers were closely linked (90.23%) with *Alectra* resistance gene.

Paper Number: 1137 (Poster Number: 81)

Evaluation of Beans (*Phaseolus vulgaris* L.) Germplasmes in 2 Agro-Ecological Zones of the Democratic Republic of Congo.

REHANI Jumaine Mkangya Jr. and Emmanuel Njukwe, IITA*

Chronic hunger, nutrient malnutrition or hidden hunger is rampant in most parts of the world especially developing countries. Although, the DRC is characterized by high potential in quality and quantity in the agricultural sector; dramatic food insecurity has been observed. In smallholder fields, the bean yield rarely exceeds 1.5t.ha⁻¹. Farmers encounter multiple constraints leading to low productivity. The poor access to improved germoplasm could be one of the biggest constraints that smallholder farmers are facing. Introduction of bio-fortified bean germplasmes could reduce food insecurity and malnutrition. The aim of this study was to evaluate the performance and to determine the best bush and climbing bean germplasmes in 2 agro-ecological zones in Eastern DR. Congo. Trials have been established in South-Kivu and Tanganyika provinces. Ten improved varieties for bush and climbing bean each have been evaluated in an experiment laid in a randomized complete block design. The means comparison between genotypes conducted by Analysis of Variance using the GLM procedure of Statistix, and supplemented by the LSD test. In both zones, yield for bush bean revealed the significant differences among varieties and villages. The high yields have been registered in HM21-7 (1.44t.ha⁻¹), RWR2245 (1.24t.ha⁻¹) and CODMLB001 (1.08t.ha⁻¹). For climbing bean in both zones, any significant difference has been observed. However, Kiangara (1.07t.ha⁻¹), CODMLV059 (0.78t.ha⁻¹) and Namulenga (0.74t.ha⁻¹) presented significant difference in the villages. The listed varieties both bush and climbing were promising and could be multiplied and disseminated to farmers in the region. Key words: Bean, variety, Moba, Mubumbano and yield.

Paper Number: 1138 (Poster Number: 82)

The Agronomic Impact of Genetically Controlled Cowpea Root Architecture.

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Cowpea (*Vigna unguiculata* (L.) Walp) productivity is constrained by abiotic and biotic soil conditions including drought, low fertility and root parasites. These resources and constraints occur in a heterogeneous and stratified pattern. Selection and breeding for beneficial root traits can improve acquisition of soil resources, avoidance of parasites and hence crop production in marginal environments. This study presents results from two seasons of manual root architectural phenotyping (shovelomics) and one season of automated image phenotyping (DIRT) on a 189 entry diversity panel of cowpea grown in the field in Limpopo, South Africa. Significant variation in root phenes was quantified and relatively high heritability was found for several root traits accessed manually as well as repeatability for traits accessed via DIRT. GWAS identified seven significant QTL from manually scored root architecture data and nineteen root architecture QTL from image analysis data. Subsequent comparisons of results from the present root architecture study with other field studies revealed QTL co-localizations between root traits and performance indicators including yield, stay green, and *Striga* resistance. This indicates root architecture may be involved in driving yield in marginal environments. The utility of the two root architectural phenotyping tools is demonstrated by revealing biologically important variation and genetic regions controlling root architecture. The data suggest root trait selection could be incorporated into breeding programs to increase production in challenging environments. Root architectural studies of other legumes such as pigeon pea, fava bean, chickpea, and groundnut could make use of the same phenotyping tools and some initial studies have already been conducted.

Paper Number: 1139 (Poster Number: 83)

Renaissance of Pigeonpea Breeding:-Hybrid Pigeonpea Technology.

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Pigeonpea occupies a prominent place in rainfed agriculture. It is an integral component of various agro ecologies of the globe mainly inter cropped with cereals, pulses, cotton, oilseeds and millets. The global pigeonpea area, production and yield (in 2013) was 6.23mha, 4.74MT and 762.4Kg ha⁻¹ respectively. The major producers of pigeonpea are India (63.74% of global production), Myanmar (18.98%), Malawi (6.07%), Tanzania (4.42%) and Uganda (1.98%). It is mainly consumed as dry split dhal besides several other uses of various parts of pigeonpea plant. Enhancing the productivity of the crop assumes specific significance mainly to combat protein malnutrition as it is the main source of protein to the predominant vegetarian population. Pigeonpea is often cross pollinated crop which paved way to exploit the advantage of hybrid vigor as in other field crops. The crop is transmuted to complete cross pollinated nature by cytoplasmic and genetic male sterility systems (CGMS) based hybrid technology. Genetic male sterility was identified in the pigeonpea crop in first phase and ICPH 8 was released based on this technology in the year 1991. But owing to high cost of seed production efforts were made to identify cytoplasmic and genetic male sterility systems (CGMS) by exploiting wild relatives of the crop. Due to intensive research efforts 8 male sterile sources were identified and designated as A1 to A8 cytoplasmic sources. Out of 8 sources, one source (A 4 from the wild relative *Cajanus cajanifolius*) is commercially utilized owing to stability of the male sterility, complete fertility restoration and appreciable amounts of heterosis. Three pigeonpea hybrids ICPH 2671, ICPH 2740 and ICPH 3762 were released for cultivation in India.

Paper Number: 1140 (Poster Number: 84)

Identifying Acceptable Improved Bean Varieties for Income and Nutrition in Zambia.

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Identifying acceptable improved bean varieties for income and nutrition in Zambia
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Abstract

Common bean (*Phaseolus vulgaris* L.) varieties customarily produced by small holder farmers in Zambia are low yielding and susceptible to diseases compared to improved varieties. The Zambia Agriculture Research Institute (ZARI) working together with the Pan Africa Bean Research Alliance (PABRA) embarked on evaluating sets of improved bean varieties from CIAT for tolerance to major constraints and preference by farmers. Twenty lines were evaluated in replicated trials at Misamfu, Kasama, in the Northern Province and at Msekera, Chipata in the eastern province between 2009 and 2012.

Paper/Poster Abstracts

These evaluations plus subsequent multi-locational on-station preliminary yield trials, advanced yield trials and on-farm farmer participatory variety selection trials resulted in the identification of lines with farmer preferred traits such as grain colour, early maturity, large grain size, good taste and marketability. Among the farmer preferred lines was the red-mottled NUA 45, which was officially released as 'Mbereshi' in Zambia in 2012. It was clear that farmers use a set of traits for selection, but often guided by a familiar background colour of grain. 'Mbereshi' has since been highly accepted by the farming community, and its demand has been remarkably increasing. It is estimated that more than 100mt of the variety will be needed in the coming years. This is likely to increase as more awareness creation of the variety is enhanced through partners such as Harvest Plus, Self Help Africa, Scaling-Up Nutrition and others. Meanwhile, concerted efforts are underway to establish sustainable seed systems at community level in response to the demand.

Keywords: Improved variety, traits, identification, release

Paper Number: 1141 (Poster Number: 85)

Introgression of Striga Resistant Genes into Cowpea Varieties in Ghana.

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ABSTRACT *Striga gesnerioides* is one of the most important constraints to cowpea production in the derived Savanna, Southern and Northern Savanna zones of Northern Ghana. Yield losses due to *Striga* range from 83% to 100%. No single method however seems to be fully adequate in the control of *Striga*. However, host plant resistance, appears to have effectively and economically controlled *Striga*. The objective of this study is to introgress striga resistance genes into improved cowpea varieties. A breeding line from IITA, IT99K-573-1-1 a resistant genotype was crossed to "Hewale" a susceptible genotype and GH3684 resistant genotype was also crossed to "Asomdwee" a susceptible genotype. The F₂ progenies obtained were genotyped with three primers (61RM2, SSR-1 and C42-2B) to determine the presence of the resistant gene which showed a band sizes of 500bp, 150bp and 280bp respectively. The phenotyping of the F₁, F₂ and Bc1 populations are also on-going in striga infested pots. Estimation of yield loss due to striga infestation is also in progress in striga free and striga infested pots. The analysis of the F₂ genotypic and phenotypic data will help to identify the perfect SSR marker (s) among the three markers based on recombination fraction, which will be deployed in marker-assisted selection. Heritability of the striga resistance genes in the two donor parents will also be determined. The effect of striga infestation on days to 50% flowering, plant height, branches and pod per plant as well as grain and biomass yield will also be determined from the yield loss assessment.

Paper Number: 1142 (Poster Number: 86)

Development and Dissemination of Drought Tolerant Cowpea Varieties in Sub-Saharan Africa.

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Cowpea is a commonly grown legume in the dry savanna regions and consumed throughout many parts of sub-Saharan Africa (SSA). Its drought tolerance ability makes it well adapted to these dry savanna agroecologies, where the bulk of the crop is produced. According to a baseline study conducted in the sub-region, demand will grow faster at the rate of 2.68% than supply at 2.55% annually from 2007 to 2030. The average grain yield of the crop is about 495 kg ha⁻¹, which is lower than the potential yield of 2,500 kg ha⁻¹ obtained under experimental conditions. Under the Tropical Legumes II project, efforts were made to overcome this low level of performance by increasing productivity in the target countries through development and promotion of new improved varieties characterised by enhanced drought tolerance and other desirable traits. FPVS were established in all countries and seeds of selected breeding lines were multiplied and tested in demonstration plots located across several communities in the countries. About 20 improved varieties were released in the participating countries. Farmers, seed growers, extension agents, NGO personnel, technicians and scientists participated in the implementation of the project and in short term trainings. Degree training of young scientists, improvement of facilities (irrigation, seed storage) and some equipment (computers, tablets...) contributed to facilitate the institution of functional cowpea breeding programs in the target countries.

Paper Number: 1143 (Poster Number: 87)

Bean Breeding Training By the Pan African Bean Research Alliance: Trainer Explanations of Training Results.

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Bean Breeding Training by the Pan African Bean Research Alliance: Trainer Explanations of Training Results Richard Miiro, Rachel Muthoni and Claire Mukankusi Abstract Investing in building breeding capacity among African scientists is critical to dealing with the continent's burgeoning food needs. An online survey was conducted to determine trainers' explanations of the variations in trainee behavioral change following short term breeding training provided by the Pan African Bean Research Alliance (PABRA). Results of 73 trainees from 16 countries show that between 70 and 90% of the trainees indicated to have achieved sufficient knowledge, skills and applied skills in the topics of field experimentation, breeding methods, pathogen isolation with disease phenotyping, and flow of breeding programs. 50% of the trainees indicated a similar level of achievement for the DNA technology topic. Application of skills was more among MS graduates than from PhDs and BS graduates. The trainer indicated that the results fitted her expectation, and explained that the high achievements for the indicated topics were due to the conduciveness of the training facilities, relevance of training to daily work of the trainees, trainees prior knowledge of the topics, presence of ongoing breeding projects, support from the trainees institutions, and support from PABRA. MS graduates applied more because they are involved in the hands on breeding programs of most of the countries, while PhDs tend to be in administrative positions. The lower trainee achievement in DNA technology topics was explained to be slow due to the lack of appropriate facilities and equipment among countries and lack of follow up by the trainer. The study is critical for the legume innovations program, as it reveals the need to pay attention to issues of trainee readiness, training conditions, institutional support, and the presence of facilities if investments in breeding training is to be effective. 1

Paper Number: 1144 (Poster Number: 88)

Molecular Characterisation of Cowpea Landraces at Genetic Resources and Biotechnology Institute (GRBI).

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ABSTRACT

Genetic diversity and phylogenetic relationships among 16 cowpea (*Vigna unguiculata*) varieties collected from the 5 agro-ecological regions of Zimbabwe was evaluated using simple sequence repeat (SSR) markers. These were composed of 13 landraces and 3 improved varieties. The seeds were planted in pots in a completely randomized block design. The plants were harvested after 3 weeks and their DNA was subsequently isolated using the CTAB DNA extraction method. The results obtained were analyzed to determine the molecular characters of the 16 cowpea varieties. A set of 20 primer combinations were developed from cowpea genomic/expressed sequence tags and evaluated for their ability to detect polymorphisms among the various cowpea genotypes. Sixteen primer combinations detected polymorphisms, with the remaining four primer sets failing to yield PCR amplification products. The informative primer combinations will be used to reveal the alleles and their loci, variation in heterozygosity among the cowpea SSRs, and the polymorphism information content. The cowpea accessions will be assayed to determine how they cluster in association with the geographical regions from which they were obtained. Results from this study will provide a framework for management and genetic improvement of cowpea germplasm in Zimbabwe.

Paper Number: 1145 (Poster Number: 89)

Participatory Variety Selection to Enhance Adoption of Cowpea Promising Lines in Northern of Nigeria.

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Farmer's Participatory Variety Selection (FPVS) was conducted in northern Nigeria in order to assess and select high yielding cowpea (*Vigna unguiculata*, L.) promising lines with better performance on biotic (Striga) and abiotic (drought) stresses. Four hundred trials were set up on-farm in farmers' field in the eighteen Local Government Areas from Kano, Jigawa and Katsina states of Nigeria during 2014 wet season, with involvement of farmers, 2 improved cowpea lines (one released and one promising line) and one local check were evaluated and selected for desirable attributes.

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In this participatory approach, farmers used different criteria to assess cowpea promising lines at the vegetative and maturity crop growth stages. Major selection criteria included the leaf appearance and texture, growth habit, pod length, maturity (early maturity and intermediate), seed color, texture and size, grain taste, grain and fodder yields. In the eighteen Local Government Areas, farmers provided valuable knowledge in identifying the promising lines of preference and therefore, indicating their competence in assessing and selecting the cowpea lines. Grain yield and maturity were the most important traits mentioned by the majority of farmers, IT99K-573-1-1 and IT99K-573-2-1, both released varieties, were selected for their high yielding and resistance to Striga. None of the local checks used in the trials was selected by farmers. Participatory varietal selection is a powerful way for farmers to become involved in the process of evaluation and selecting promising line adapted to their own needs, systems and environments.

Key words: Grain yield, Maturity, disease infection, FPVS.

Paper Number: 1146 (Poster Number: 90)

Improving Drought Tolerance in Chickpea (*Cicer arietinum* L.) Using Marker Assisted Backcross Breeding (MABC).

*Paul Kiprotich Kimurto**, Egerton University

Improving drought tolerance in chickpea (*Cicer arietinum* L.) using marker assisted backcross breeding (MABC)

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Chickpea is gaining commercial importance in East Africa due to its nutritive value and its role in cereal-legume cropping systems. This study introgressed root quantitative traits through marker assisted backcrossing to enhance drought tolerance. Two high yielding well adapted and drought susceptible chickpea varieties (Saina K1-ICCV 95423 and ICCV 10) were selected as a recurrent parent using ICC 4958 as root donor parent using MABC. Six SSR molecular markers (CaM1903, ICCM0249, NCPGR127 and NCPGR21, CaM204, TA118 and TA113) were used to tract the QTL in each cross from F1. The identified true heterozygotes were used as donors and backcrossed to the recurrent parent to obtain BC1F1 seeds, then repeated to BC3F1, selfed to obtain BC3F3. SNP markers used for background selection to recover background of recurrent parents while retaining the root traits. A total of 24 lines (ICCV10 x ICC 4958) and 20 lines (Saina K1 x ICC 4958) were obtained and evaluated at Koibatek for two seasons. The 13 best progenies had better root traits, drought resistance and yield than the recurrent parents (17-47% seed yield and 12-43% biomass), better rooting depth (RDp), total root length (TRL) and root length.

Key words: Drought tolerance, Marker Assisted Backcross (MABC), . SNP markers, Donor parent, Recipient parent, Quantitative trait loci (QTL)

Paper Number: 1147 (Poster Number: 91)

Assessment of the Genetic Diversity and the Relationship Among Common Bean (*Phaseolus vulgaris* L.) Accessions from DR-Congo Germplasm Using SSR Molecular Markers.

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The genetic diversity of Common bean accessions from the germplasm of INERA in DR-Congo was assessed to understand their phylogeny relationship using SSR molecular markers. A set of 91 accessions, comprising 21 from CIAT/Columbia, 36 from Mvuazi, 30 from Mulungu and 4 from Gandajika, were genotyped with 12 SSR markers that generated 89 alleles with an average of 7 alleles per locus. Polymorphism information content (PIC) value was 0.64 indicating a fair diversity with a range of 0.40-0.82. The average heterozygosity level per locus was 0.24. The variability was as low as 1% among the populations, 64% within individual and 35% within population. Clustering analysis based on the genetic similarity grouped the 91 Common bean genotypes into 2 main distinct clusters. Information generated from this study can be driven to select parents for breeding or develop hybrid lines for yield increase, high biomass, resistance against abiotic/biotic stresses and segregating populations to map genes/QTLs for yield in Common bean in the western DR-Congo.

Paper Number: 1148 (Poster Number: 92)

Screening Cowpea (*Vigna unguiculata* (L) Walp) for Resistance to Flower Bud Thrips (*Megalurothrips sjostedti* Trybom).

*Gonne Sobda**¹, *Ousmane Boukar*², *Jonathan Ayertey*³, *Bernard Pangirayi Tongoona*⁴ and *Christian Fatokun*², (1)Institute of Agricultural Research for Development (IRAD), (2)International Institute of Tropical Agriculture (IITA), (3)West Africa Centre for Crop Improvement (WACCI), University of Ghana, PMB LG 586 Legon, (4)West Africa Centre for Crop Improvement (WACCI), University of Ghana, PMB LG 586 Legon

Cowpea (*Vigna unguicula*) is an important legume in various regions of the world where it serves both for human consumption and animal feeding. Cowpea productivity is limited by insects among which flower bud thrips (*Megalurothrip sjotedti*) is the major pest during flowering. The objective of the present study was to identify good sources of resistance/tolerance to cowpea flower bud thrips. Two hundred (200) cowpea genotypes including 180 collections from farmers' fields in the north and the far north regions of Cameroon, 17 lines from IITA, two farmers' preferred varieties from IRAD, and one line from SARI, Ghana were screened at two locations and in the screenhouse at IRAD, Maroua during the rainy season 2015. The data collected included the number of thrips per flower and the visual scoring of the damages caused by thrips using a scale of 1-9 based on a combination of varying intensities of browning of the stipules, non-elongation of peduncles and flower bud abscission. The results revealed that the following cowpea genotypes showed some level of resistance/tolerance: TVU889, TVU72, NGT115 and sanzi. They recorded scores of less than 3.0 both in field and screenhouse trials. Further studies should be conducted to confirm the status of TVU889, TVU72 and NGT115 which are potential new sources of resistance for *M. sjostedti*. The cowpea line, sanzi was confirmed as a resistant line and could be used as donor of thrips resistance at IRAD, Cameroon.

Key words: Cowpea, Cowpea flower bud thrips, control measure, screening, resistance, tolerance.

Paper Number: 1149 (Poster Number: 93)

Marker-Assisted Introgression of Large Seed Size QTLs into a Cowpea Cultivar from Senegal.

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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, genetic markers (SNPs) are being employed to introgress two QTLs (Css-1 and Css-4) for large seed size from the recombinant inbred line "113-4-6-14-1" (CB27/IT82E-18 x CB27) into "Pakau," a new popular cultivar in Senegal. Recently, a 60k assay genotyping platform has been developed for cowpea and used for genotyping the CB27 x IT82E-18 population, in which Css-1 and Css-4 were mapped previously (Lucas et al. 2013, Front Plant Sci.). A total of 16566 high quality SNPs segregated in this population, and were used in QTL mapping to identify new SNPs within the seed-size QTL regions. These SNPs will be used for marker-assisted backcrossing to incorporate Css-1 and Css-4 into Pakau. Four possible combinations will be analyzed to test the effect on seed phenotype of these QTLs in the Pakau genetic background: no QTL, each of the two QTLs, and both QTLs. Output of this work will contribute to the development of new cultivars more suitable for the targeting market. Future studies will include determining the effect of increasing seed size on both yield and the nutritional quality of cowpea.

Paper Number: 1150 (Poster Number: 94)

Breeding Runner Bean for Short -Day Adaptation, Grain Yield and Disease Resistance in Africa.

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Runner bean (*Phaseolus coccineus* L) is grown in high altitudes (>1800masl) of eastern Africa where common bean (*Phaseolus vulgaris* L) is poorly adapted. However, its productivity is poor because farmers rely on low yielding landraces which are susceptible to diseases. Available long-day vegetable-type varieties are poorly adapted to tropical conditions. Our objectives were to develop breeding populations and select for new high yielding, disease resistant, grain-type short-day lines suitable for cultivation under tropical conditions. Four populations were developed from crosses between a long day (White Emergo) and short-day landraces at Kabete, and advanced to F5 as population bulks. Selected F5 plants were advanced through single pod descent method. F6.8 lines were evaluated at two locations in 2012 and 2014. Results showed significant (P

Paper Number: 1151 (Poster Number: 95)

Grain Yield and Protein Content of Brazilian Cowpea Genotypes Under Diverse Ugandan Environments.

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Twenty nine cowpea genotypes, including four Ugandan genotypes, were evaluated for grain yield, protein stability and adaptability under diverse environments in a randomized complete block design with three replications. The analysis showed that cowpea grain yield and protein content were significantly ($P < 0.01$) affected by genotypes (G), environments (E), and interaction (G x E). Genotypes C2T and C2I had the highest grain yield and protein content respectively, but both were only adapted to specific environments. Genotypes C1J, C1V, C2A, C2O, and C2R were adapted to three environments with high yield which was stable. Similarly, genotypes BRS Pujante, C1J, C2Q and CIT also expressed high protein levels with high stability and wide adaptability. The study further revealed that Namulonge 2014B, Serere 2014A, Serere 2014B and Serere were the most favorable environments for obtaining high yield and protein respectively, because at these four environments, mean yield and protein were higher than the overall mean. All Brazilian genotypes had high protein levels compared to Ugandan genotypes indicating the potential of Brazilian genotypes in improving cowpea seed protein content in Uganda. Keywords: Stability, Adaptability, AMMI, GxE Interaction.

Paper Number: 1152 (Poster Number: 96)

Morphovariability and Agronomic Characteristics Among Common Bean Accessions from the Democratic Republic of Congo (DR-Congo) Germplasm.

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Common bean (*Phaseolus vulgaris* L.) is one of the most important grain legumes in the world in term of total production and nutrition. It was domesticated in America, and spread around the world. This crop is cultivated in a very large part of Africa, extent in 30 sub-Saharan Africa countries. But only a fraction of its accessions has been characterized based on origin, morphometric traits, agronomic performance and seed composition. This objective of this study is to characterize morphologically and agronomically the Common bean accessions from DR-Congo germplasm, highlight the level of high variability in the Common bean gene pool of the Country. 81,11% of Common bean accessions from the germplasm had losangic leaves and 18,99% triangular leaves. 50% of plants had white color of flowers, 35,56% of pink color and 14,44% of rosatre white color. Pods colors frequencies were 85,56% yellow, 6,67% red, 6,67% green and 1,11% crimpson. 31,11% of accessions had seeds with white color, 21,11% of brown color, 18,88% of yellow color, 6,67% of red color, 3,33% of brown chestnut color, 2,22% of striated color, 2,22% of cream-coloured color, 2,22% of chocolate striated cream-coloured, 2,22% of red mottled color and 9,99% various the accessions colors (1,11% pink, 1,11% red dark, 1,11% red checkmate, 1,11% red striated white, 1,11% yellow checkmate, 1,11% grey sink, 1,11% grey striped, 1,11% light crimson and 1,11% crimson with white points). The stems colors were 78,89% green, 20% anthocyanin and 1,11% red.

Paper Number: 1153 (Poster Number: 97)

New Sources of Resistance to Bean Rust Established with SSR Markers in Uganda.

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Common bean rust, caused by *Uromyces appendiculatus*, is an emerging disease in Uganda that is known to cause 100% yield losses in susceptible cultivars worldwide. Breeding for host resistance to rust is challenging because of its high variability that makes phenotypic selection of sources of resistance difficult. Therefore, the identification of sources of resistance using marker selection to complement phenotyping is pertinent and timely in the process of developing durable host resistance adaptable to Uganda. In this study, 24 simple sequence repeat (SSR) markers that are highly informative and linked to rust resistance were used to genotype 143 common bean germplasm in Uganda. These consisted of 30 landraces, 20 improved varieties and 93 introduced accessions including the 12 rust differential lines. Although, 22 markers showed amplifications in this genetic background, only 6 markers with PIC of about 0.4 were useful in tracing the different resistant genes.

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The cluster analysis of the SSR diversity performed using the DarWin software detected 2 major groups, with 4 subgroups indicating presence and absence of rust resistance genes. The first major group contained 16 cultivars, which included 2 landraces (Kamuli red and U00236) and 14 introduced cultivars. Four cultivars, Mexico 235; Mexico 309; Oura Negro and Redland pioneer, with previously known rust resistant genes occurred in this group and are thus suitable as donor parental lines. This study will guide on further analyses in mapping genomic regions associated with rust resistance in the identified promising parental lines that may be useful in breeding for common beans rust resistance in Africa. Keywords: *Uromyces appendiculatus*, Host resistance, Darwin software

Paper Number: 1154 (Poster Number: 98)

Towards the Breeding of the Ideal Cowpea for Northern Ghana.

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Cowpea is the second most important food legume in Ghana in terms of human consumption. The crop is mainly cultivated for its grains in Ghana where consumers prefer large white seeded types. The parasitic weed "Striga gesnerioides" infestation is among the major limitations to cowpea cultivation in many parts of Africa including northern part of Ghana. Breeding efforts resulted in striga resistant cowpea lines recently for the region. However, these lines lack the large seed size which is a consumer trait of the crop in Ghana. We identified eight SNP markers that associated significantly with both seed thickness and weight which are the determinants of seed size in cowpea. One marker each was located on Linkage Groups 1, 5, 7, 10 and 11 while three were on LG 4. These SNPs are within earlier discovered QTLs for seed size in cowpea. The potential of these loci to improve seed size of cowpea were also confirmed. Utilization of the seed size SNP markers in marker assisted breeding is anticipated to improve the seed size of the striga resistant cowpea lines. Cowpea varieties with large seeds and resistant to striga in northern Ghana would be almost ideal for the region. These would contribute to the attainment of the sustainable development goals 1 and 2. The CSIR - PGRRI and SARI together with other partners would collaborate to develop the anticipated ideal cowpea for northern Ghana.

Paper Number: 1155 (Poster Number: 99)

Participatory Varietal Selection of Common Bean (*Phaseolus vulgaris* L.) with Peasants Based on the Morphometric and Agronomic Characters.

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This research was undertaken within the frameworks of the participative varietal selection of common bean, associating the agronomic research (INERA) and the peasants of Nkolo in Kongo Central province (DR-Congo). It was based on an evaluation and selection starting from thirty varieties of the germoplasm of the Antenna of the National Grain Legume Program (PNL) of INERA at Mvuazi, and whose seven varieties were preselected by the peasants by taking account of the agronomic requirements, economic, organoleptic and of the consumers. The work strategy aimed the maintenance of the co-operation between researchers (breeders in particular) and peasants for the evaluation of the germplasm varieties with the aim of developing a selection which take into account the country knowledge and the factors of the gender like a way of improvement of outputs and acceptance of the common bean crop by the peasants. To this end, seven varieties Ngwaku-ngwaku, Moore 88002, Mvuazi (T-3), Ntomo (A 445), Manseki, NK 011/08 and PVo 14 were selected, and considered to be very favorable by the peasants, in the equality of the gender and the capacities of men and women, for the development and the releasing of the promising varieties to the peasants, of the grouping of Nkolo, of the province and of the region. Present research agreed the vocation to pose the first steps of this participative selection of the common bean varieties with the aim of the true and durable maintenance of food safety and the reduction of the poverty of target populations at the base.

Paper Number: 1156 (Poster Number: 100)

Breeding Beans with Bruchid and Multiple Virus Resistance.

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Bean common mosaic virus (BCMV) and bean common mosaic necrosis virus (BCMNV) are worldwide threats to dry bean (*Phaseolus vulgaris* L.) production. Beans planted in the lowlands of Central America and the Caribbean also need resistance to Bean golden yellow mosaic virus (BGYMV).

The common bean weevil (*Acanthoscelides obtectus* Say) and the Mexican bean weevil (*Zabrotes subfasciatus* Boheman) can cause significant losses in seed yield and quality of the bean crop. Although the use of insecticides is a common practice to control the bean weevil, this option may be unavailable or too expensive and potentially dangerous for many small-scale farmers. The development of bean lines with resistance to bean weevils would decrease the damage caused by these pests and allow small-scale farmers to store beans for consumption or sale in local markets. The principal objective of this research was to develop tropically-adapted Mesoamerican race (black, small red and white) and Andean (red mottled, sugar, yellow and white) bean lines that combine bean weevil and BGYM, BCMV and BCMNV resistance. A secondary objective was to evaluate the effectiveness of the bruchid resistance when breeding lines are exposed on small-scale farms to different species and ecotypes of bruchids. A longer-term objective is to collaborate with North Dakota State University (NDSU) researchers to develop robust molecular markers for bruchid resistance. The bruchid resistance was derived from the cross 'Rojo*3 / SMARC 2-PN-1 // ICA Pijao*2 / G40199' made by Dr. Paul Kusolwa of Sokoine University of Agriculture and Dr. Jim Myers of Oregon State University. The dark red kidney breeding line AO-1012-29-3-3A was selected from this population in Puerto Rico for resistance to the bean weevil. AO-1012-29-3-3A also has the *I* and *bc-12* genes that confer resistance to BCMV and many pathotypes of BCMNV. AO-1012-29-3-3A was used as a progenitor to develop black bean breeding lines that combine bruchid resistance with genes for resistance to BGYM, BCMV and BCMNV. Results from a trial conducted in Honduras found AO-1012-29-3-3A and the black bean breeding lines to have resistance to the Mexican bean weevil. During the upcoming year, the performance and bruchid resistance of the black bean breeding lines will be tested in Honduras, Guatemala and Haiti. A second cycle of crosses has produced breeding lines with small red, white, red mottled, yellow and sugar bean seed types that are currently being screened for resistance to bruchids and resistance to BGYM, BCMV and BCMNV. NDSU scientists have identified putative markers for the APA locus which contributes to bruchid resistance.

Paper Number: 1157 (Poster Number: 101)

Assessment of Phenotypic and Genetic Variation Among a Subset of Elite Pigeonpea Genotypes in Kenya.

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Molecular marker information supported by quality morphological data facilitates the choice of suitable parents for applied breeding. The main aim of this study was to assess the response of 16 yield elite pigeonpea lines to pod borer and to determine the extent of genetic variability among the 16 accessions in comparison with known pigeonpea breeding lines (39) available at ICRISAT-Nairobi. The 16 genotypes were screened during the April - October 2014 long-rains at Marigat, Koibatek and Fluorspar. Genetic diversity was determined using 21 simple sequence repeat (SSR) markers evenly distributed across the genome. Response of the genotypes to pod borer attack was significant ($P \leq 0.05$) with three genotypes (ICEAPs 01541, 01542-2 and 00902) revealing moderate levels of resistance. The 21 primer pairs detected 80 alleles from 55 accessions with a mean of 3.9 alleles per locus and polymorphism information content (PIC) ranging from 0.09 to 0.75 and an average of 0.39. Seventy-eight alleles were detected from the 16 elite lines with a mean of 3.7 alleles per locus and PIC ranging from 0.13 to 0.7. However, clustering based on Neighbor Joining, grouped the 55 genotypes into three main clusters based on their pedigree. The findings of this study revealed relatively narrow genetic diversity among the 16 genotypes using both morphological and molecular markers. The three genotypes (ICEAPs 01541, 01542-2 and 00902) identified may be used as source of resistance. Future studies should focus on broadening genetic base by including landraces and wild relatives to maximize selection and improve breeding value.

Paper Number: 1158 (Poster Number: 102)

Evaluation of Selected Pigeonpea [*Cajanus cajan* (L.) Millsp.] Genotypes for Resistance to Insect Pest Complex in Dry Areas of North Rift Valley, Kenya.

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Pigeonpea is an important pulse crop that has gained importance in semi-arid tropics, although its yield potential has not been fully realized due to biotic and abiotic stresses that limit its production. Insect pest complex of pod borer (*Helicoverpa armigera*), sucking bug (*Clavigralla tomentosicollis*) and pod fly (*Melanagromyza cholcosoma*) are the major limiting factors to its production causing up to 100% yield loss. The experiment was carried out in three varied sites (Marigat, Koibatek and Fluorspar) with the aim of evaluating resistant genotypes to insect pest complex in dry parts of North Rift Valley Kenya using 16 ICRISAT elite genotypes. Significant ($P \leq 0.05$) differences in grain yield performance, incidence and severity of the insect pests was revealed in all sites. The damage was more severe in Marigat (Pod borer-37.2%, Sucking bug-39.3% and pod fly-5.9%) than ATC- Koibatek (Pod borer-1.9%, Sucking bug-8.4% and pod fly-5.9%) and Fluorspar (Pod borer-3.6%, Sucking bug-6.8% and pod fly-2.9%). Genotypes ICEAPs 00850, 00902, 01541 and 1154-2 showed potential levels of resistance to the insect pest complex and high yields. Grain yield associated negatively ($P \leq 0.05$) with pod borer and sucking bug damage and non-significance with pod fly damage. The potential genotypes identified in this study need to be further evaluated in two seasons and in other locations to validate these findings to be used in breeding program.

There is need for identifying mechanisms of resistance to this insect pest complex to reduce yield loss and achieve the potential yield.

Paper Number: 1159 (Poster Number: 103)

Common Bean and Cowpea Improvement in Angola.

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During 2014 and 2015, the Instituto de Investigação Agronómica (IIA) evaluated the performance of common bean [*Phaseolus vulgaris* (L.)] breeding lines and improved cowpea [*Vigna unguiculata* (L.) Walp.] varieties. The field experiments were planted in the lowlands at Mazozo and in the highlands at Chianga. These breeding lines and cultivars have combinations of genes for resistance to pests and diseases and tolerance to drought, low soil N and high temperature. The main objective of this study was to select the best breeding lines in terms of adaptability, seed type, maturity, resistance to angular leaf spot and rust, and seed yield. PR0401-259 performed well at both Mazozo (792 kg/ha) and Chianga (925 kg/ha), while the national average yield is 500 kg/ha. PR0637-116 produced a mean seed yield of 833 kg/ha at Mazozo. W6-16489, Kasukanywele, Kigoma, Uyole 96, Sacramento performed well at both sites. The common bean cultivar Kilombero produced the highest seed yield at Chianga (1,767 kg/ha) and W6-16429 yielded 1,521 kg/ha at Mazozo. Beniquez and W6-16489 were resistant to angular leaf spot. Several improved and local cowpea varieties were well adapted at Mazozo and Chianga. The cowpea cultivars 124/2469-1, 124/1375-3, 124/2783-4, IT82E-18 produced seed yields > 1,000 kg/ha which is four times the national average of 250 kg/ha. The cowpea variety 124/2469-1 produced the highest seed yield (1,498 kg/ha). The most promising bean and cowpea lines will be considered for local release and will be used as parents in a breeding program to develop improved varieties for Angola.

Paper Number: 1160 (Poster Number: 104)

Diversity of Iron and Zinc Concentration in Seed and Phenotypic Characterization of Common Bean Genotypes.

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Malnutrition is a major contributor to infant mortality in Sub-Saharan Africa and deficiency of micronutrients such as iron, zinc and vitamin A affect at least half of the world's population. Utilization of bio-fortified crops in diets provides a feasible and sustainable option to address malnutrition. Common bean (*Phaseolus vulgaris* L.) a leading staple after maize in East and Central Africa (ECA) is a good source of bioavailable iron and zinc. However, the concentration of these micronutrients is highly variable among bean genotypes, ranging from 55ppm to 110ppm for iron and 25ppm to 60ppm for zinc. This study sought to identify superior genotypes with high iron and zinc among the regional nurseries for the ECA region. Over 300 genotypes were evaluated in replicated trials under field conditions at Kawanda in Uganda, and seed iron and zinc concentrations was assessed using X-ray Fluorescence (XRF) technology at the Rwanda Agriculture Board laboratory in Rubona. Our findings showed high variability ($P \leq 0.001$) in seed iron and zinc concentration among these genotypes ranging between 44 and 90ppm for iron and 24-47ppm for zinc. Germplasm with >75ppm iron, >35ppm zinc, and with desirable agronomic traits and high yield are being promoted in the region as high iron beans for adoption, or used as parents to develop bean germplasm with >90ppm iron and >35ppm Zinc taking into consideration the traits relevant for variety adoption and early breeding.

Key words: Common bean, Iron, Zinc, bio-fortification

Paper Number: 1161 (Poster Number: 105)

Development of Cowpea Genotypes through Induced Mutation.

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Cowpea (*Vigna unguiculata* L.) is an excellent source for dietary proteins and micronutrients in Zambia. It is faced with several constraints including low yielding varieties, abiotic and biotic stresses, and crop production ranging from 200 to 800 kg/ha against a potential of 3,000 to 4,000 kg/ha. Induced mutation with gamma radiation has generated genetic variation affecting a wide range of plant characters within the shortest period of time. The overall objective of the study was to promote productivity and production of cowpea among smallholder farmers and enhance their access to the market in the cowpea value chain. The specific objectives of the study were to develop new genetic sources of cowpea with high yielding potential and with tolerance to pests and diseases through induced mutation. Dry and disease-free seed of cultivars (Lutembwe, Bubebe and Msandile) cowpea varieties were irradiated with gamma radiation at 100 Gray for Msandile and 150 Gray for Lutembwe and Bubebe cowpea varieties.

The pedigree method of selection was used. Selection was within family until homozygosity. Thereafter, selection among families was carried out for desirable traits. Highly significant variation was obtained with induced mutation for maturity, phenological characteristics, yield components, tolerance to storage pests of bruchids and to aluminium (Al) toxicity. Significant variation was also obtained in seed coat colour and level of antioxidants in grain of the mutants compared to their respective parent. In Bubebe and Msandile a small number (5) were earlier or later in maturity than the parents. In Lutembwe, mutants developed were predominantly (82.8%) later in maturity than the parent. This will enable mutants to fit in environments not suitable to their parents. Yield improvements over the parent were obtained in 20 of the mutants. The yield increase varied from 30% to the highest of 172% for LT11-3-3-12 mutant. Mutants were identified with high tolerance to Al toxicity. No or reduced lime application will be required so that these cultivars should enable less costly cowpea production in previously unsuitable areas. Mutants were identified with high bruchid tolerance. Use of resistant mutants will reduce postharvest losses, storage protection costs and use of hazardous and expensive pesticides. There was variation in seed coat colour which was associated with level of antioxidants. Genotypes which had high (3.47 mg /100 mg CE) had darker seed coat colour (yellowish brown and purplish brown) compared to lower values for white (0.17 mg/100 mg CE) seed coat colour. Consumption of cowpea cultivars with high antioxidant levels could prevent health problems such as Heart attack, Hypertension, Obesity and Cancer.

Paper Number: 1162 (Poster Number: 106)

Genetic Mapping of Striga and Thrips Resistance in Cowpea Population in Northern Ghana.

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Cowpea is one of the most important legume crop in the semi-arid tropics. It is a multifunctional crop, providing food for man and livestock. Cowpea production is hampered by biotic and abiotic constraints. Among these constraints are *Striga gesnerioides* and *Megalurothrips sjostedti* infestation. One of the best strategies to control these pest is the use of resistant lines which fit in all cropping systems, compactible with other control measures and environmentally safe. The current study seek to identify quantitative Traits Loci (QTL) for Striga and Thrips resistance associated with two breeding lines of SARI. A 270 Recombinants Inbred lines (RILs) derived from a cross between 'SANZI' (resistant to Thrips) and IT97K-499-35 (resistant to Striga) is the subject for this study. This population was adopted by the Legume Innovation Lab SO1.A5 and FTF Innovation Lab for Climate Resilient projects and leaf samples based on Single Seed Descent (SSD) have been sampled to University of California Riverside to be genotyped on the SNP platform. Seeds generated from the plants of the single seed are currently being phenotyped through field experiment for Thrips and field and pot experiments for Striga. Preliminary results has led to the selection of individuals that did not show Striga emergence on the field, these will be validated in pot experiment to check for attachment. Eventually, QTL for Thrips and Striga associated with this population will be identified for future use in marker-assisted breeding and individuals that combine both genes will also be selected for further evaluation and release.

Paper Number: 1163 (Poster Number: 107)

Developing "Dwarf" Climbing Beans through Induced Mutation.

Evans Kaimoyo*, University of Zambia

Beans are an important crop for food and nutrition security, cash income and agro ecosystem improvement. There are three categories of common beans based on their growth habits namely; dwarf, semi-climbers and climbers. The outstanding characteristics of climbing beans are their high height which can be over 4 m and high yield potential of up to 6 tonnes per hectare, 2 to 3 times more than the dwarf type. They are late maturing and take 100 to 120 days to physiological maturity. They exhibit better resistance to fungal diseases and are more tolerant to water stress. The crop can be grown in small spaces such as backyard gardens; creating a high reproductive, sustainable agricultural ecosystem that provides ground cover, good weed control, high biomass and elevated nitrogen fixation. They also provide a reliable source of employment due to continuous harvest (both green and dry harvest). There is therefore, a good alteration for both food security and income generation. There are, however, problems of proper staking material because of the plant height of the crop. The project aimed at developing desirable bean varieties from climbing beans with high-yielding potential but with reduced maturity and height but still maintain the yield quality and quantity through induced mutation. There was highly ($p < 0.001$) significant variation in maturity and plant height with induced mutation in the climbing beans MAC 49, MAC 23 and MAC 12 in the study. In MAC 23, the highest grain yield of 5339 kg/ha was obtained with MAC 23-916-5-3 earlier in maturity but with a plant height of 2.1 m, 18.2% lower than the parent. In MAC 23 -124-1-3, the maturity was reduced from late to early, while the height was similar to that of the parent. The yield of 4192 kg/ha was however higher than that of the parent. In the case of MAC 23-124-1-3 both the maturity (early) and the height (0.8 m) were reduced but the grain yield (4,192 kg/ha) was 41.0% higher than that of the parent. There was similar pattern for MAC 49 and MAC 12. Mutation induction reduced the maturity period and also the plant height, while the grain yield increased. Induced mutation has proven useful for generating variation to transform climbing to "dwarf" bean while maintaining or increasing the yield relative to the parent variety.

Paper Number: 1164 (Poster Number: 108)

Deployment of the Cowpea Aphid Resistance Gene for Cowpea Improvement in Ghana.

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Cowpea, *Vigna unguiculata* (L.) Walp is an important source of protein for human nutrition in many parts of the semi-arid tropics (SAT). The major cause of the low yields of cowpea are insect pests, diseases, drought and low soil fertility. Among the major insect pests of cowpea is *Aphis craccivora*, which is very important at the vegetative stage of the crop. The use of aphid resistant varieties is important component of integrated management of the pest at the vegetative stage. The objective of this study was to demonstrate the effectiveness of the aphid resistance locus identified in SARC 1-57-2 in reducing damage from the cowpea aphid in Ghana. Using an F2 population developed from Apagbaala x SARC1-57-2, the resistance locus was tagged with the SSR marker CP171F/172R with a recombination fraction of 5.91%. Based on the CP171F/172R, recurrent marker assisted backcrossing was carried out to introduce the resistance locus into the susceptible cultivar, Zaayura. This led to the development of several BC4F3 lines that are isogenic except for the region of the resistance locus. Collaboration between Kirkhouse Trust and University of California under the Legume Innovation Lab led to background selection of the BC4F1 lines on the SNP platform. This led to selection of lines that have recovered 95% of the background of Zaayura, the recurrent parent. The selected lines are currently being evaluated in replicated on-farm. The lines will eventually be submitted to the national variety release and registration committee for assessment and approval for release as a variety.

Paper Number: 1165 (Poster Number: 109)

Durango Diversity Panel: Abiotic and Biotic Stress Characterization and Potential for Introducing New Germplasm into East Africa.

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The Durango Diversity Panel (DDP) consists of 192 old and newly released North American cultivars and germplasm lines in the pinto, great northern, red, and pink bean market classes. The Durango Race provides genetic diversity for drought stress tolerance, and biotic stress resistance. Much disease resistance in the DDP, however, is likely derived from smaller seeded Mesoamerican gene pool introgressions. Commercial potential for the pinto bean market class in Africa is growing but evaluation of pinto beans and other race Durango materials for production in East Africa is needed. In 2015, the DDP was evaluated in Arusha and Mbeya, Tanzania. Yield ranged from 400 to 1600 kg ha⁻¹ and 100 seed weight from 20 to 37 g. Bean rust disease pressure was severe but 15% of the DDP exhibited resistance to the different race complexes across locations. Fourteen DDP lines were selected for on farm trials and preference evaluation in Tanzania in 2016. The DDP was planted under separate non-stress, terminal drought, low N, and purgatory stress trials in Washington State (WA) in 2015. Agronomic, root, and remote sensing traits (greenness and thermal imaging) via UAV were collected. About 5% of the DDP exhibited combined abiotic stress tolerance in WA with high yield potential and rust resistance in Tanzania. Preliminary GWAS with SNPs reveals important genomic regions in the DDP conditioning traits relevant to abiotic stress tolerance and biotic resistance. Collectively, this information will be useful for breeding Durango market class cultivars across continents.

Paper Number: 1166 (Poster Number: 110)

Genetic Relatedness of Cowpea Aphid Resistance.

Godfred Agyeman Duah, University for Development Studies, Francis Kusi, CSIR - Savannah Agricultural Research Institute and Nelson Opoku, University For Development Studies*

Cowpea is one of the most important dietary staple in tropical Africa. The cowpea aphid (*Aphis craccivora*) is a major pest of cowpea that causes damage right from the seedling to pod bearing stage. The use of resistant varieties appears to be the best option for farmers in the tropics owing to its low cost. It has been observed that cowpea aphid resistant lines developed earlier show differential effects on aphid population from different geographical areas. The legume Innovation lab project has put together sources of aphid resistant panel to be screened at selected locations in West Africa and California Riverside. In Ghana, the seedling screening at SARI Station at Manga has observed that 5 lines show resistance to aphids. The resistant lines would be crossed to a known susceptible line from Ghana, this is to determine the mode of inheritance of each of the lines found to be resistant. The resistant lines will also be crossed to each other to determine whether the same gene controls the resistance in them or not. Knowledge on the genetics of aphid resistance in these lines will help in accelerating the breeding program in future, including pyramiding of different resistant genes in cowpea genotypes. The sources of aphid resistant panel have already been genotyped on the SNP platform and polymorphic markers have been identified.

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The phenotypic data that will be generated from the current study will therefore facilitate genetic mapping of the aphid resistance gene and its deployment in marker assisted selection.

Paper Number: 1167 (Poster Number: 111)

Breeding Efforts for the Improvement of Climbing Beans for the Guatemala Highlands.

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Maize and beans are the main staple food in most poor households in Guatemala. Per capita bean consumption is approximately 9.4 kg per year. Since few other sources of protein are available, this amount is not enough to ensure an acceptable nutritional quality, especially within poor households in the highlands. Chronic malnutrition is frequent among children under 5 years old in the western highlands, with 67% of children affected, making Guatemala the country with the highest malnutrition level in the western hemisphere. Intercropping (locally known as Milpa) is the main production system in the highlands, where maize-bean is the most common crop association. Unfortunately, on-farm productivity of these climbing beans is approximately one third of their genetic yield potential mostly due to the lack of improved cultivars that are able to withstand biotic and abiotic stresses. Fungal and bacterial diseases as well as pests are the main cause for yield reductions. In addition, production is made with almost no inputs of fertilizers and/or other chemicals. Historically, climbing beans have received less attention and breeding efforts worldwide in comparison with the bush-type beans commonly grown in the lowlands, as shown by the significant yield gap between regions. The objective of this project is to create a breeding pipeline focused on the genetic improvement of climbing beans adapted to the highlands in Guatemala by: i) using some improved populations to release a first generation of improved climbing beans, ii) doing a molecular characterization of a germplasm collection of 600 accessions, iii) doing a baseline study to understand better the main breeding targets, and iv) establishing a new breeding pipeline by making new crosses every year, mostly focused on disease/pest resistance.

Paper Number: 1168 (Poster Number: 112)

Developing Improved Cowpea Varieties for Multiple Agro-Ecologies in Ghana: The Role of Genotype By Environment Interactions.

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Cowpea (*Vigna unguiculata* L. Walp) is considered the most important food grain legume in the dry Savannas of tropical Africa. In Ghana, cowpea is an important source of vegetable protein and minerals for over 70% of the populace. However, cowpea production is constrained by a number of factors including pests, diseases, drought and declining soil fertility. These challenges are confounded by the variations in agro-ecological zones which are characterized by different edaphic, agro-climatic and biotic factors. The cowpea pest *Melgalurothrips sjostedti* (Thrips) and the *Cercospora* leaf spot disease present major challenges to cowpea production in tropical Africa. In this study, thirteen elite cowpea lines were developed through the introgression of Thrips (*Melgalurothrips sjostedti*) and *Cercospora* leaf spot resistance into well adapted genotypes. The thrips resistance was obtained from the landrace Sanzisanbili, IT82D-716 and TVX3236 whereas The *Cercospora* leaf spot resistance was obtained from Marfo-Tuya, Apagbaala, SARC 4-75 and IT97K-499-35. The lines developed were evaluated across three major agro-ecologies in Ghana (Forest, Forest-Savannah transition and Coastal Savannah) for two years. The lines were assessed for their yield potential, adaptation and other agronomic attributes. Significant genotype-by-environment interactions were observed for days to 50% flowering, days to maturity and grain yield. Four lines (CRI-(8)-1, CRI-11(9)-2, CRI-11(9)-3 and CRI-11(9)-5) were recommended for further evaluation on farmers' fields. To determine which environmental factors was most sensitive for grain yield, we partitioned the environment component of the total variation into three environmental factors viz, rainfall, temperature and day length.

Paper Number: 1169 (Poster Number: 113)

False Constitutive QTL for Shoot Dry Weight in Cowpea [*Vigna unguiculata* (L.) Walp] Detected in Different Environments.

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Epistasis as a genetic component of variation is often neglected in QTL mapping while stress-specific gene regulation might affect the detection rates and approximate genomic locations of QTL. In addition, QTL by environment (QE) interactions identified simply by comparing results from different environments may lead to bias results. A population of 88 F11 recombinant inbred lines (RILs) derived from 58-77 x Yacine cross was phenotyped for shoot dry weight (SDW) in two locations under high (30kg P /ha and low phosphorus (0 kg P/ha) conditions. Experiments were repeated in the screenhouse with soils from both fields, constituting eight environments. Variety 58-77 is resistant to flower thrips, with high biomass and high N₂-fixing ability. Based on a linkage map of 372 EST-derived SNPs markers from GoldenGate assay, a total of 32 QTL were mapped on all 11 linkage groups (LG) by Win Cartographer with r² values of 0.1 to 0.5. QTLnetwork identified only two main QTL on LGs three and ten with QE effects. Additionally, five epistatic QTLs were identified, distributed on eight LGs with three pairs having significant epistasis main effect and all five having epistasis x environment effects. A false "constitutive" QTL (qQTL SDW3.4) detected in four environments by Win Cartographer, was not detected by QTLnetwork across the eight environments. The results of this study indicates comparing QTL from different environments to identify QTL by environment interactions leads to bias results and epistasis is common among loci not individually significant for trait effects.

Paper Number: 1170 (Poster Number: 114)

Screening and Genetic Studies of Drought Tolerance Among Sari Favorite Lines.

*Patrick Attamah** and *Patrick Attamah**, Kwame Nkrumah University of Science and Technology

Paper Number: 1171 (Poster Number: 115)

Introgression of Drought Tolerance Quantitative Trait Locus (QTL) in an Elite Kenyan Chickpea (*Cicer arietinum* L.) Genotype Using Marker Assisted Backcross Breeding (MABC).

*Moses omondi Oyier**, Egerton University

Introgression of drought tolerance quantitative trait locus (QTL) in an elite Kenyan chickpea (*Cicer arietinum* L.) genotype using marker assisted backcross breeding (MABC)

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<align="center">ABSTRACT

Drought is the most important constraint affecting production of chickpea and other crops as well. Quantitative traits like drought tolerance are multigenic and their inheritance is difficult to predict hence the need to explore more precise breeding techniques like marker assisted selection. The aim of this study was to introgress the identified root trait QTLs into Kenyan adapted cultivar to enhance drought tolerance through marker assisted backcrossing. Genotype Chania Desi 1 (ICCV 97105), was selected as a recurrent parent for improvement among ten agronomically superior elite cultivars after exhibiting high polymorphism with SSR markers. Five molecular markers (CaM1903, CaM1502, TAA 170, NCPGR21 and GA11) were validated for use in MABC deployed in this study. Crosses were made between Chania desi 1 and ICC 4958 followed by marker screening of the F1 seedling progenies for the QTL of interest. Identified true heterozygotes were used as donors and backcrossed to the recurrent parent to obtain BC1F1 seeds. The process was repeated to obtain BC2F1 and finally BC3F1 with molecular marker identification of seedlings carrying the QTL region at each step. The results indicated that it is possible to transfer QTL that confers drought tolerance using MABC. The two sets of seeds viz: BC3F1 and BC2F2 were multiplied in the field and preserved for further evaluation to validate the contribution of the introgressed QTL in improving drought tolerance and yield.

Key words: Marker Assisted Backcross (MABC), Drought tolerance, Donor parent, Recipient parent, Quantitative trait loci (QTL)

Paper Number: 1172 (Poster Number: 116)

Screening and Genetic Studies of Drought Tolerance Among Sari Favorite Cowpea Lines.

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The amount of rainfall, distribution of rainy days and the duration of the rainy season affect different growth stages of cowpea in northern regions in Ghana and eventually reduces yield. Drought escape by most early maturing cowpea varieties has made them varieties of choice in most areas where there is terminal drought. However the occurrence of long dry spells especially at the beginning of the rainy season cause high yield losses in early maturing varieties. The study was setup to identify SARI's favorite breeding lines that are tolerant to both vegetative (intermittent) and reproductive stage (terminal) droughts and to study the genetic structure of traits that are highly correlated with yield under both drought conditions. A total of 30 lines that has been genotyped on the SNP Platform under Legume Innovation Lab, including released varieties, improved lines and genotypes from IITA and University of California Riverside were screened for intermittent and terminal drought using "Wooden Box Technique" and field screening respectively. For the intermittent drought screening, ceasing watering for 14 days after emergence of first trifoliolate was enough to differentiate genotypes. Ten out of the thirty lines had mean survival rate above 50%. The relationship between drought screening traits (DST) and yield under both terminal and terminal drought and their genetics will be studied. The information on the genetic structure and control of DST that are significant and highly correlated with yield under both drought condition in a set of parents will make breeding for drought programs more effective.

Paper Number: 1173 (Poster Number: 117)

Agronomic Qualities of Multiple-Disease-Resistant Pyramids Developed with Marker Assisted Selection (MAS) in Common Bean.

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Diseases affect common bean productivity, while co-infections cause complete crop loss in susceptible cultivars. Genetic resistances are cost-effective for disease control especially in farmer's fields. Therefore, core genotypes with resistance to major diseases; Angular leaf spot, Anthracnose, Bean Common Mosaic Necrosis Virus (BCMNV) and Pythium root rots, were developed using marker assisted selection (MAS) to minimize linkage drags. Resistance genes from Mesoamerican parents (Co42&Co5 from G2333; Phg2 - MEX54; Pult - MLB49-89A and I &bc3 - MCM5001) were pyramided, backcrossed thrice to G2333 and selfed to F₆, for high yields. Earliness, number(s) of internodes, flowers, pods and seed per plant, seed shapes and colors, flower colors was used to evaluate agronomic qualities using incomplete block designs with three replications in field trials at CIAT, Kawanda in 2015. Treatments were; genetic pyramids and blanks (genotypes lacking six genes pyramided), parents and checks (NABE12C, NABE29C and K132). Data was analyzed using mixed-models of the RELM algorithm, while log-likelihood ratios and Chi-square were used for testing models. Difference were highly significant ($p < 0.01$) among treatments, blocks and models ($F_{2,1010} = 29.414$). G2333 had the highest (361) number of seeds per plant, but backcrossing resulted in high-yielding lines, with increased number of seed per plant (270 - 290) and earliness (95-100 days). Increase in number of flower buds recorded did not necessarily result in increased pod formation and grain yield from trait correlations ($r = -0.67$, $P < 0.01$). Implications of this study for developing lines with resistance to diseases and high yields are further discussed.

Paper Number: 1174 (Poster Number: 118)

Inheritance of Extra-Early Maturity in Cowpea.

Emmanuel Yaw Owusu, CSIR - Savannah Agricultural Research Institute, Richard Akromah, Kwame Nkrumah University of Science and Technology, Francis Kusi, Savanna Agricultural Research Institute (SARI) and Nicholas Denwar, CSIR-Savanna Agricultural Research Institute*

Earliness is an important component of adaptation of crops to any agro-ecological zone especially in sub-Saharan Africa, which is associated with abiotic stress factors. Extra-early maturing cowpea cultivars escape mid-season/terminal drought and heat stress. Apart from their importance in cropping systems, they also provide an early harvest to bridge the hunger period before harvest of full season crops. In areas where two cropping seasons occur, they provide additional seed for the main season cropping. However, reports on heritability estimates for extra-early maturing cowpea cultivars are rare. Hence a research was conducted to investigate the inheritance of the trait by incorporating extra-early maturity genes from Sanzi into the most farmer preferred medium maturity cowpea cultivar; Padi-Tuya.

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No significant differences ($p > 0.05$) were observed in F1 and RF1 progenies indicating the absence of maternal effect on the inheritance of extra-early maturity in the genotypes studied. Broad sense heritability for the four maturity parameters studied varied from 75% to 99% while narrow sense was 74% to 99%. These high heritability estimates implies selection for improvement in F2 will be very effective. Additive and non-additive gene effects with their interactions contributed significantly to the inheritance of the trait studied suggesting it is under polygenic control. These findings indicate the test materials can be improved for extra-early maturity varieties using selection/backcross methods. A breeding programme based on the above findings is ongoing and leaf samples from 98 extra-early maturing cowpea accessions have been taken for genotyping to fast track the breeding process.

Paper Number: 1175 (Poster Number: 119)

Cowpea (VIGNAUNGUICULATA (L.) Walpers) Genotypes Respond Differently to (STRIGAGESNERIOIDES (WILLD.) Vatke) Infestation Across Environments in Northern Nigeria.

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Cowpea is one of the most important grain legumes in sub-Saharan Africa where it is widely grown and used as cash crop, food for humans, feed for livestock, and contributes to improve land fertility. However, its production is constrained by several biotic stresses including the parasitic weed *Striga* which causes severe yield loss up to 100 % especially under combined drought and low soil fertility conditions. Twelve cowpea genotypes were cultivated in two naturally *Striga* infested environments (Minjibir and Malam Madori) in Northern Nigeria with the objective to evaluate (i) the genotypic difference in plant growth and yield and (ii) the extent of *Striga* infestation and effects across the environments in 2013 and 2014 rainy seasons. *Striga* infestation was lower in Minjibir compared to Malam Madori across the genotypes (3 vs. 11 *Striga* plants per m², respectively). B301, IT03K-338-1, IT97K-499-35, IT99K-573-1-1, IT99K-573-2-1, UAM09 1055-6 and UAM09 1056-2 appeared to be resistant/tolerant to *Striga* and were able to some extent maintain higher yields across the two environments. In contrast, IT81D-994 and VYA showed significantly lower yields in Malam Madori than in Minjibir due to higher *Striga* pressure in the first environment. Pod and grain yields were significantly and negatively correlated with *Striga* count. The infestation of some resistant checks by *Striga* in Malam Madori supported the hypothesis that there may be a new *Striga* biotype/race in Northern Nigeria. These results confirmed previous findings and therefore could be useful in cowpea breeding programs for varietal improvement.

Keywords: Cowpea, adaptation, parasitic weed, environment, yield, Sudan savanna.

Paper Number: 1176 (Poster Number: 120)

Effects of Different Priming Methods, Varying Priming Durations on Enzyme Activities in the Germinating Chickpea Seeds (*Cicer arietinum* L.).

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Abstract

This study aimed to assess the effect of some priming methods and priming durations on alpha amylase activities and germination of chickpea advanced lines of ICCV 97105 in Kirinyaga County, Kenya in 2012/2013. An experiment was conducted at Mwea Irrigation Agricultural Development Centre (MIAD) shaded tunnel to evaluate alpha amylase activities (moles/ml) in the soaked seeds and the number of seeds that germinated (plants/m²) under no priming, hydro priming and halo prime at three levels, that is, 0.1, 0.2 and 0.3% NaCl₂ concentration with three priming durations (8, 10 and 12 hrs). The experiment was laid out in complete randomized design (CRD) with three replications. The control treatment was the untreated (none soaked) seeds. The highest ($P < 0.05$) alpha amylase activity of 12.97 moles/ml, was with HCL1T8 treatment, i.e., halo priming for 8 hrs with 0.1 % NaCl₂. This treatment combination was also statistically equal to HYT10 (12.70 moles/ml), HCL2T12 (12.43 moles/ml) HLC1T12 (12.07 moles/ml), HCL2T8 (12.07 moles/ml), HCL2T10 (12.03 moles/ml) and HYT8 (8.20 moles/ml). Non primed seeds (control) had significantly the least enzymatic activities (7.05 moles/ml) and least number of plants/m² at germination. In conclusion soaking chickpea seeds in priming solutions (i.e., water for 8 and 10 hours and saline solutions of 0.1% NaCl₂ for 8 and 12 hours; 0.2% NaCl₂ for 8, 10 and 12 hours) was useful in enzymes production that can bring about sufficient increase in enzymes activities at sowing and improve on number of germinating seeds (plants/m²). Farmers not willing to do halo priming do hydro priming for 8 hrs (HyT8) and 10hrs (HyT10).

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This will increase alpha amylase activities and consequently improve seed germination that's essential if farmers are to realize optimal crop stand in their farms.

Key words: Chickpea, priming, alpha amylase activities, germination (plants/m²).

Paper Number: 1177 (Poster Number: 121)

Determination of Grain Yields and Grain Yield Attributes of Desi Chickpea (*Cicer arietinum* L) Under Some Priming Methods, Durations Varying Initial Soil Moisture Levels.

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Determination of grain yields and grain yield attributes of desi chickpea (*Cicer arietinum* L) under some priming methods, durations varying initial soil moisture levels

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The study aimed to assess some priming methods and durations under varying field capacities of water in Kirinyaga County in Kenya in 2012/2013 growing seasons. A two season field experiment was conducted at Mwea Irrigation Agricultural Development Centre (MIAD) farm to evaluate chickpea advanced lines of ICCV 97105 for grain and grain attributes under no priming, hydro priming and halo prime at three levels, that is, 0.1, 0.2 and 0.3% NaCl₂ concentration with three priming durations (8, 10 and 12 h) and varying initial soil moisture levels 100% field capacity (FC, 75, 50 and 25% FC). The experiment was laid out in a split plot design with three replications, pre sowing irrigation, combined priming method and priming duration allocated in the main, and sub-plots, respectively. The control treatment was the pre-sowing irrigation at field capacity (FC). The results revealed that the number of pods/m² were highest (1,631 and 566) in both seasons I (Oct 2012 to Jan 2013) and II (July 2013 to Oct 2013), respectively under pre sowing irrigation of 75% FC. Consequently the highest grains yields of 1177.0 and 513.1 kg/ha were obtained, respectively. In both seasons HCL1T8 (0.1% NaCl₂ for 8 h), significantly produced higher number of pods/m², that is, 1615 and 754. Interaction effects of irrigation and priming on grain yield (kg/ha) during both seasons revealed that pre sowing irrigation of 75% FC, halo priming with 0.1% NaCl₂ for 8 h and 100% FC hydro priming for 8 h produced 1562.0 and 1788.0 kg/ha, respectively in season I and 755.0 and 748.3 kg/ha, respectively in season II. It was concluded that farmers are recommended to apply pre sowing irrigation of 75% FC or above before sowing their seeds and halo prime the seeds with either 0.1% NaCl₂ for 8 h, or 0.2% NaCl₂ for 12 h or 0.3% NaCl₂ for 10 h to produce 1562.0, 1604.0 and 1460.0 kg grain/ha, respectively. Farmers not willing to do halo priming can apply pre sowing irrigation of 100% FC and do hydro priming for 8 h (HyT8). This will yield significantly higher grain yields of up to 1788.0 kg/ha under good rainfall conditions and proper management practices.

Key words: Chickpea, priming, pre sowing irrigation, grain yield.

Paper Number: 1178 (Poster Number: 122)

Community Perceptions on Agro- Biodiversity Conservation of Bambaranut *Vigna Subterranea* : A Case of Mutoko District Zimbabwe.

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The food security crisis that is affecting most rural communities in Africa calls for development from within and the need to build on local initiatives. Previous studies have concentrated on production of cereal and legume crops focusing on improved varieties at the expense of locally adapted crops such as bambaranut. As a result the biodiversity of such neglected species is at threat. A study to elicit community perceptions on bambaranut biodiversity and to characterise local landraces for cultural and institutional memory was carried out in three main farming sectors namely Communal Area, Resettlement Area and Small Scale Commercial Farming Area of Mutoko district in Zimbabwe. The multidisciplinary, descriptive and exploratory study was mostly qualitative supported by quantitative laboratory results on seed characterisation. The results were presented in the form of a case study in which 17 farmers (4 men and 13 women) and 10 stakeholder institutions participated. At least 20 bambaranut landraces were characterised according to 3 main categories dark coloured, light coloured and animal like characteristics. The study resulted in the conservation of 75 new samples in the National Gene Bank and the community samples at household level were raised from 6 to 12. Awareness and interest on the need for agro-biodiversity was raised during farmer days in which 195 farmers participated. The case study provides any opportunity for scaling up, hence the need to advocate for policy issues that mainstream agro-biodiversity in agricultural extension. This will ensure alternative and sustainable sources of food and nutrition security at community level. The food security crisis that is affecting most rural communities in Africa calls for development from within and the need to build on local initiatives. Previous studies have concentrated on production of cereal and legume crops focusing on improved varieties at the expense of locally adapted crops such as bambaranut. As a result the biodiversity of such neglected species is at threat.

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Paper Number: 1179 (Poster Number: 123)

Impact of Leaf Harvesting Intensity, Interval and Duration on Growth, Yield and Nutritional Composition of the Black-Eyed Bean Cowpea Type (*Vigna unguiculata* L. Walpers).

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In Zimbabwe farmers grow cowpea for vegetable leaves and grain consumption. Farmers acknowledged the practice of leaf harvesting without consideration of the impact on grain yield. Evaluation of the impact of leaf harvesting intensity and interval on leaf and grain yield, growth and nutritional composition of black-eyed bean (determinant) compared to landraces (indeterminate) was done in Mutoko District and University of Zimbabwe. The experiment was a three-factor factorial, with cowpea variety (BEB and landrace), leaf harvesting intensity (one leaf, two leaves and three leaves) and leaf harvesting interval (weekly and fortnightly) in a randomized complete block design with three replications. Leaf harvest began 4 weeks after crop emergence and was terminated at the 50% flowering stage. Leaf harvesting weekly significantly increased leaf and decreased grain yield, in contrast to fortnightly leaf harvests. Increase in leaf harvesting intensities significantly increased leaf yield and decreased grain yield. Black-eyed bean produced higher grain (> 800kg/ha) and lower leaf yield (<500kg/ha) in all intensities, intervals and on both sites than landraces. Nutritional content increased with increases in leaf harvest intensity for leaves ash, calcium, carbohydrates, fat, fibre and phosphorus. Black-eyed bean produced the highest leaf nutritional content of ash, carbohydrates, fat, and protein and fibre, while landrace had the highest nutritional content of phosphorus and potassium. Leaf harvesting reduces grain yield and should be restricted to a maximum of two leaves fortnightly to allow farmers to benefit from both leaves and grain. Effects of leaf harvesting on biological nitrogen fixation should be researched on.

Paper Number: 1180 (Poster Number: 124)

Narrowing Common Bean Yield Gap and Improving Productivity Using Organic Soil Amendments within Smallholder Farming Systems of Sub-Saharan Africa.

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Common bean is mainly grown as intercrop in maize without soil fertility amendment leading to low yield in Malawi. As beans enter international markets, sustainable intensification will be eminent. This study was conducted during 2014-15 season to assess bean yield and varietal response to soil fertility amendment and cropping systems. Yield in pure stands treated with chicken manure were higher (0.76 - 1.85 ton ha⁻¹) while control plots without manure and the business as usual fertilizer application in maize intercrop gave low yields (0.4 - 1.0 ton ha⁻¹). Manure application significantly increased overall grain yield by 60% in sole bean stands and 53% in bean-maize intercrops over the control. Bean yield in the common practice of maize intercrop was higher by 15% in manure compared to NPK treatments. Combining manure and NPK resulted in 9% yield gain over manure treated stands in sole crops while in intercrop, the yield gain was 27 and 11% over the merely fertilizer and manure treatments, respectively. In sole cropping, manure plus fertilizer treatment gave higher yield for SER 83 while SER 45 performed better under mere manure. When intercropped with maize, SER 45 responded to fertilizer plus manure treatment while SER 83 showed no response. The study shows that use of chicken manure on small farms would significantly increase bean yield and improve fertilizer use efficiency of some varieties under maize mixed farming systems. It also reveals that the impacts of soil management options are specific to bean varieties.

Paper Number: 1181 (Poster Number: 125)

Development and Selection of New Cowpea (*Vigna unguiculata* L. Walp) Lines Adapted to Sahelian Traditional Cropping Systems.

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In the Sahel, cowpea is a major component of the complex traditional cropping systems, where it is widely grown in mixtures with millet, sorghum, groundnut, sesame, etc.. in various combinations. However, the productivity of cowpea is very low in these mixtures, mainly due to competition under intercropping, lacks of crop protection and soil fertility management measures and low plant population density. Therefore, the need for developing improved varieties that could enhance cowpea productivity under these systems. The main objective of this study was to develop new cowpea lines with high yield and adapted to two cropping systems (sole and millet-cowpea intercropping). An experiment was carried out at Tarna research station (Maradi) in 2014, where thirty six (36) cowpea lines were subjected to a square lattice design (6x6) with three replications. These cowpea lines consisted of thirty two (32) breeding materials deriving from different crosses made and four local checks. The results revealed that cowpea genotypes were significantly influenced by cropping systems. Genotypes x cropping systems analysis have shown specific varietal behavior according to the environmental constraints studied. Under millet-cowpea intercropping IN11-01-02, IN11-02-90, IT99K-573-1-1 and IN11-01-22 with relatively 69%, 64%, 61% and 60% expressed the highest percentage of their potential compared to sole cropping for grain yield. Also, higher fodder yield potential was expressed by IN11-02-63 (72%), IN11-02-68 (68%) and K VX-309-6G (68%). These cowpea genotypes have shown flexible adaptation to the existing cropping systems. Nevertheless, future studies should look at combinations of more factors that enable adaptation to the complex cropping systems. Key words: Cowpea lines, adaptation, cropping systems, millet-cowpea intercropping and sole cropping.

Paper Number: 1182 (Poster Number: 126)

Improved Production Systems for Common Bean in South-Central Uganda.

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Common bean (*Phaseolus vulgaris* L.) is the most important grain legume in Uganda, with per capita consumption exceeding 50 kg year⁻¹ in some regions. Common bean is an important crop in Uganda because it is a common source of calories. It is also a major source of dietary protein that often substitutes for meat and other protein rich animal products, which the poor can rarely afford. Unfortunately, beans managed under conventional systems have a yield gap of about 75% and production continues to remain low due to several constraints. We hypothesized that the development of improved bean production systems would increase grain yields when increasing input levels and utilizing improved pest management practices, especially with newly-developed bean cultivars. To narrow this yield gap, we conducted a field study in Masaka District, Uganda to determine whether our improved bean production systems could significantly increase yield. We found that increasing management level, irrespective of season, and planting bean cultivars tolerant to common bean diseases improved grain yield. The increase in yield can most likely be attributed to the differences in planting arrangement and density, fertilizer application, improved N fixation, and weed and pest management. All of the inputs used for the improved management systems were obtained locally, except the rhizobia, suggesting that increased yields are obtainable by farmers. These results suggest that common bean production systems that increase the use of agricultural inputs and improve pest management strategies are acceptable methods for farmers to alleviate constraints limiting bean production in south-central Uganda.

Paper Number: 1183 (Poster Number: 127)

Conservation Agriculture Tillage Practices on Soil Quality and Bean Yields in Eastern Kenya.

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Abstract Soil fertility depletion is one of the key challenges limiting food production in Eastern Kenya where different bean (*Phaseolus vulgaris* L.) varieties are grown by smallholder farmers under complex and risky farming systems. In the effort of providing sustainable approach for alleviating the problem, a four season study was conducted at the Kenya Agricultural and Livestock Research Organization (KALRO-Embu) farm on South-Eastern slopes of Mt. Kenya at 000 33.18'S; 0370 53.27'E and 1425 m asl. The study aimed at evaluating and recommending suitable conservation agriculture (CA) tillage practices for improved soil productivity and bean yields. The trial was laid out on a randomized complete block design with three replicates. A newly released bean variety (Mwende) was the test crop whose performance was monitored under conventional (CVT) and two CA tillage practices; furrows/ridges (FR) and zero tillage (ZT). Data collected included soil quality, crop yields and water use efficiency (WUE) resulting from adaption of the various tillage practices. Result showed improved soil quality and bean performance particularly under the CA tillage practices.

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For example, lower soil pH values and higher soil organic carbon (SOC) and phosphorus (P) concentrations were noted under the CA based treatments compared to the tested CVT farming method. On average across the season, the bean grain yield was improved from 0.5 to 2.3 t ha⁻¹ after adapting good farming methods. The study recommended for further testing and promotion of feasible CA farming practices for improved soil productivity and beans production in Eastern Kenya.

Paper Number: 1184 (Poster Number: 128)

Participatory Testing of Isfm Technologies on Bio-Fortified Bush and Climbing Beans Production in Rwanda.

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Scaling up the ISFM for Improved livelihoods remains a crucial key to improve livelihood in Rwanda. This study aimed to promote the use of input technologies for improved production of bio-fortified bush (RWR2245) and climbing (MARC44) beans and assess the level of acceptability of new technologies by farmers. On-farm demonstration trials were installed in two agroecological zones of Rwanda namely central plateau and Bugesera. In each zone two sub-sites were selected. Sites selection criteria used are the proximity of the market as well as micro-climate differences. In Bugesera agro-ecological zone we selected Gashora and Mareba sectors and in Central Plateau Runda and Kayenzi were used for demonstration. The treatments under evaluation where NPK, rhizobium or the combination of rhizobium and inorganic fertilizer. The results revealed that Climbing and Bush beans grain yield and dry matter were higher in the treatments combined NPK and Rhizobium and averaged 1.5 ton ha⁻¹ compared to 0.8 for the farmer's practices, the use of rhizobium alone yielded 1.2 tons ha⁻¹. In addition, rhizobium application has significantly increased grain yield (p

Paper Number: 1185 (Poster Number: 129)

Maize-Common Bean/Lupine Intercrop Productivity and Profitability in Maize Based System of Northwestern Ethiopia.

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Intercropping of common bean and lupine with maize is a recent phenomenon in maize-based cropping system of Northwestern Ethiopia. Thus, there is little information on the role this practice plays on the framing system of the region. Field experiments were conducted at two sites in Northwestern Ethiopia during the 2012 and 2013 growing seasons to determine the effect of intercropping of common bean (*Phaseolus vulgaris* L.), narrow-leaf lupine (*Lupinus angustifolius* L), and white lupine (*Lupinus albus* L) with maize (*Zea mays* L) under two intercrop planting arrangements, and sole cropping of each species on productivity and profitability of the cropping system. Results indicated maize yield was maintained, while adding the legume yield in the intercrop system. The equivalent yield of maize and land equivalent ratio were on average 18 and 42%, respectively, higher with intercropping compared to sole cropping. Maize-common bean with single and paired row intercrop planting arrangements, and the maize-narrow leaf lupine with the paired row intercrop planting arrangement produced 28, 23, and 20% more equivalent yield of maize compared to maize sole crop, respectively. The associated increases in net return were 22, 17, and 15%. The results demonstrated enhanced productivity and economic return of maize-common bean and maize-narrow leaf lupine intercropping, which could be scaled up in the maize based cropping system of Northwestern Ethiopia for increasing household food security and sustainable intensification. Further study is required to evaluate more legume species which can be compatible to maize intercrop system. Keywords/phrases: Equivalent yield of maize; Land equivalent ratio; *Lupinus albus* L; *Lupinus angustifolius* L; *Phaseolus vulgaris* L; *Zea mays* L.

Paper Number: 1186 (Poster Number: 130)

Common Bean Improved Variety Impacts on Profitability and Smallholder Farmers' Income.

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Legumes are important food and cash crops in developing countries. In Tanzania, more than half the farmers grow several species of pulses. However, productivity of all pulses is low and far below potential and this has impacted on profitability. This paper evaluates on-farm profitability of beans by smallholder farmers as well contributors to the observed profit levels. Multistage sampling procedure was used to select a sample of 200 households from Babati district of Tanzania. Smallholder farmers' gross margin as a proxy of profitability was analysed using Gross Margin Analysis procedure.

Moreover, socio-economic factors determining common bean on-farm level gross margin were analysed using Multiple Regression Analysis approach. Factors influencing household common bean supply to the market were analysed using Binary Logistic Regression method. Lastly, the major constraints affecting common bean supply to the market were analysed using descriptive statistics and content analysis technique. The average productivity of local and improved bean variety was 240.56Kg/acre and 281.43Kg/acre respectively. At farm-gate, improved bean variety fetched an increased price of 46.24% per Kg. Moreover, at the market level, improved bean variety sold a 64.24% increase in prices as compared to farm-gate. Local bean variety realized an increased price of 10.12% at farm-gate and 28.74% at market level. This indicates that, improved bean variety fetched more by 32.80% at farm-gate and 32.15% at market level per Kg. The average bean produce was 358.70Kg and 72.095Kg per season, per smallholder farmer, for local and improved variety respectively. The average farm-gate prices were TZS 962.18/= (US\$0.48) and TZS 1,161.67/= (US\$0.58) per Kg for local and improved variety correspondingly. The average total revenue of common bean per smallholder farmer at farm level was TZS 428,884.57/= (US\$214.44) / acre per season. The smallholder farmer's Gross Margin was TZS 311, 483.56/= (US\$155.74) per season. Socio-economic factors influencing the profit margin were; farm-gate price, gender, access to market information, land size, off-farm income, education level and yield.

Table 1: Regression results of factors affecting common bean's gross margin

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Educational level (X1)	0.142	0.082	-0.129	1.735	0.085
Farm-gate price (X2)	0.134	0.023	0.450	5.928	0.001
Land size (X3)	8.340	0.473	6.254	-0.373	0.002
Gender (X4)	8.477F-02	0.021	0.306	4.085	0.001
Yield (X5)	679.010	46.800	0.902	14.509	0.000
Household size (X6)	-1.502F-02	0.21	-0.052	-0.724	0.470
Off farm income (X7)	-106263.719	32796.173	-0.164	-3.240	0.001
Market information (X8)	7.866E-02	4.377	14.653	3.347	0.001
Farming experience (X9)	-2253.242	1440.107	-0.116	-1.565	0.119

The results showed that a relationship existed between the gross margin and the socio-economic factors as explanatory variables included in the model. The coefficients of farm-gate price, land size, gender, market information and yield had positive signs, implying that these variables had a direct relationship with common bean gross margin. As more of these variables are engaged, there will be an increase in the amount of gross margin realized by smallholder farmers. On the other hand, the coefficients of education level, household size, farming experience and off-farm income had negative signs, implying inverse relationship with the amount of gross margin. This agrees with a priori except education level. The a priori expectation of the sign of coefficient of education level should be positive. The negative sign could be attributed to the fact that in some parts of the study area there were smallholder farmers with few years of formal education but were consistently producing high quantities of common bean. The reason might be, regardless that most of common bean farmers in Babati district had low education level, they may have had various trainings on bean production and or marketing and this may have substituted formal education. Illegal actions (use of re-calibrated weighing scales which steal from farmers and lying about the actual market prices) by middlemen, inadequate processing facilities, and counterfeit seeds, low producing seeds, poor markets, shortage of inputs, diseases and pests, shortages of extension services and dearth of market information were the main challenges facing smallholder farmers. In the context of bean production, there is need for the Ministry of Agriculture, Food Security and Cooperatives (MAFSC) to take lead in interventions towards improvement of farmers' extension service and training which will be attributed as approaches for fighting killer diseases such as early-blight, and pests like aphids. Trainings suggested are on correct pesticides use, and growing common bean improved seed varieties. Improved varieties were relatively more productive, pests and disease resistant as compared to local varieties. Moreover, the National Beans Programmes carrying out research in the country are advised to have proper mechanisms of disseminating and monitoring new seed varieties to farmers. This is because, most of farmers either have not heard about the new variety or fail to differentiate between Quality Declared Seeds (QDS) and counterfeit.

Paper Number: 1187 (Poster Number: 131)

A Cross-Site Integrated Impacts Assessment and Trade-Offs of Adaptation Packages to Climate Change.

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We explore how maize-beans smallholder cropping systems in Lushoto (Tanzania) and Rakai (Uganda) might intensify and/or diversify through an adaptation package that includes i) application of organic manure, ii) inorganic fertilizer, iii) improved varieties iv) irrigation and, iv) inorganic fertilizer +irrigation. The paper applies the Tradeoff Analysis model for Multi-Dimensional Impact Assessment (TOA-MD), to simulate technology adoption and associated economic, environmental and social outcomes. Our results indicate that all the assessed scenarios have expected adoption rates of between 40 to 65%. The mean net farm income increases by over 20% per farm per year, whereas the per capita income increases by between 15 and 30% for the whole population.

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Conversely the population poverty rates decreases by about 5 to 12%. Even though climate change negatively impacts maize and beans, the adoption of inorganic fertilizer+ irrigation had the greatest impact to offset the climate effects. Further research is needed to understand how to address current barriers to adoption in addition to the trade-offs of improved technologies, especially with regard to strategies that introduce environmental risks and expose farmers to costs.

Paper Number: 1188 (Poster Number: 132)

Maize-Grain Legume Intercropping: Ecological Intensification to Enhance Resource Use and Production Efficiency for Smallholder Farmers in Northern Ghana.

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Intercropping is practised by many smallholder farmers in northern Ghana for household food and income security. We evaluated effects of maize-legume intercropping patterns on resource use efficiency and productivity of maize and grain legumes under different field fertility types in two sites in savanna agroecologies. Treatments tested were maize-legume within-row, 1:1 and 2:2 distinct rows of maize and legume (cowpea, soybean and groundnut) and their respective sole crops. Intercropping improved photosynthetically active radiation (PAR) interception relative to sole maize. Mean % intercepted PAR (IPAR) at maximum plant biomass were: within-row (86), 1:1 (80) and 2:2 (77) for maize-cowpea; while sole cowpea and maize intercepted 93 and 68 respectively. Land equivalent ratios (LER) indicated intercrops were relatively productive than sole crops with values ranging from 1.3 to 1.9, 1.1 to 1.7, 1.0 to 1.7 for within-row, 1:1 and 2:2 intercrops respectively signifying better efficiency and productivity with within-row system. Intercrops in fields poor in soil fertility had superior LER (ranged from 1.1 to 1.9) than those in fields with high soil fertility (1.0 to 1.6). Intercrop grain yields followed similar trend as IPAR and LER with highest intercrop yields (cowpea-2.06; soybean-1.79; groundnut-0.82; maize-3.07 t ha⁻¹) achieved with within-row. Maximum grain yields of sole crops (t ha⁻¹) were: legumes (cowpea-2.18; soybean-2.46; groundnut-1.09) and maize (3.78). Results show that with maize-grain legume intercropping we can achieve higher LER, for that matter higher resource use efficiency and grain productivity in poor fertility fields, safeguarding household food and income security.

Paper Number: 1189 (Poster Number: 133)

Multilocation Evaluation of Drought Tolerant Bean Lines in Uganda.

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Intermittent and sometimes terminal drought constrains common bean (*Phaseolus vulgaris* L.) production in Uganda and many other regions within east and central Africa and as such identification of drought tolerant cultivars is crucial for sustainable intensification of bean production in the region. The aim of this study therefore, was to evaluate a set of 12 pre-selected (SCN1, SCN 11, SCN 8, SEN 56, SEN 46, SEN 80, SEN 70, SEN 95, SEN 98, SCR 26 & SCR 35) drought tolerant lines in comparison with five (5) market class Ugandan bean varieties (NABE 4, NABE 15, NABE 16, NABE 2 & K132) in eight drought prone regions of Uganda to identify suitable lines which combine drought tolerance and yield potentials for possible utilization in these areas. Eight genotypes were selected from two seasons' evaluation in 2014A and 2014B. The selected genotypes were evaluated in the same eight on-station sites with twenty-two on-farm sites to carry out farmer participatory selection. Measurements taken included plant stand count at four weeks after planting, percentage ground cover, trifoliolate leaf number at four weeks after planting, number of plants harvested, average number of pods per plant, average seeds per pod and yield at harvesting. Analysis of variance among genotypes and drought prone environments was performed using Genstat statistical package (14th edition). Results obtained were of significantly ($P \leq 0.005$) wide variation in the average genotypic performance of measured traits within and among environments. Genotypes SCN 11, SCN1, SCR26 and SEN 80 had the best mean yields while ABI, NGETTA and RAKAI were the best environments. As far as grain yield production was concerned, Rakai was the best environment for the genotypes with an average yield of 1797.4 kg ha⁻¹ while NaSARRI with an average yield of 72.3 kg ha⁻¹ was the worst environment. In all SCN 11 was the best performing genotype with an average of 1095.3 kg ha⁻¹ while K132 was the worst with 555.2 kg ha⁻¹

Key words: Bean genotypes, Environments, Drought tolerance, Yield

Paper Number: 1190 (Poster Number: 134)

Improving the Productivity of Cotton/Cowpea Intercropping System in the Subhumid Savanna of Nigeria.

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Abstract Cowpea (*Vigna unguiculata* L. Walp) is the most important food legume while cotton (*Gossypium hirsutum* L.) is a major industrial crop in the savannas of West and Central Africa. Both crops are often intercropped by smallholder farmers but their yields are low mainly due to insect pest attack and adoption of sub-optimal agronomic practices. Being an industrial crop, farmers apply insecticides to cotton while cowpea rarely receives insecticidal protection. Experimental assessment of the effect of insecticide application and spatial arrangement on the productivity of this intercrop indicated that the cowpea crop that depended on insecticide drift from cotton yielded 40-160% higher than unsprayed sole cowpea. The productivity of this mixture could be improved by intercropping two rows of cotton with one row of cowpea on ridges spaced 75 cm apart or by intercropping cotton and cowpea in the same row in alternate stands. Results from sowing date experiment showed that the best time to introduce cowpea to July-sown cotton is two to four weeks after planting cotton. However, extra-early maturing photo-insensitive varieties could be introduced as late as six weeks after cotton without yield reduction. On-farm studies revealed that relaying cowpea into July-sown cotton in the same row in alternate stands was more productive than alternating two rows of cotton with two rows of cowpea. The local photosensitive cowpea was better adapted to this system than the improved photo-insensitive varieties. The implication is that appropriate improved cowpea varieties for cotton/cowpea intercropping in the subhumid savanna should be spreading and photosensitive.

Paper Number: 1191 (Poster Number: 135)

The Role of Beans in the Milpa Production and Dietary Systems of Guatemalan Highlands: Results of a Farm Household Survey.

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The indigenous Mayan population of the western highlands of Guatemala is one of the most undernourished in the world. Beans are widely grown in this region and considered one of the best sources of nutrients. Research indicates that household energy consumption from own-produced beans can be significantly enhanced by increasing bean yields. To help guide research efforts to increase bean productivity, a survey of 548 farm households was conducted in March-April 2015 to better understand the current status of the climbing bean-maize intercropping, also known as the milpa system. Results indicate that bean is one of the two most important crop grown in this region as measured by area planted. Most of the beans are produced for home consumption; less than 10% of farmers produced beans for sale in the market. Own production covers less than half of annual bean consumption for 23% of farmers and between 50-75% for 33% of farmers. Once beans from own production have been consumed, 50% of farmers purchase beans at least once a week. Households with children (under 14) on average served beans to the children 3 days a week. This is one of the first representative farm survey of bean growers in the region. The descriptive and econometric analysis of this data has helped gain a better understanding of farmer characteristics, bean production practices in the bean-maize intercropping system, the role of beans in household food consumption. This analysis contributes towards establishing priorities for the climbing bean breeding program targeted for increasing the productivity of the milpa system.

Paper Number: 1192 (Poster Number: 136)

Groundnut-Pigeon PEA Doubled up INTER-Cropping Systems in Malawi.

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Abstract

Groundnut production in Malawi is mainly concentrated in Central region particularly in Lilongwe, Kasungu and Mchinji (The groundnut Triangle) although production is country wide. Traditionally, the crop is grown in sole cropping. However, the ever increasing land pressure and the need for crop diversification is forcing many farmers to intercrop their groundnuts with other legumes such as soybeans, pigeonpea, common beans and many others. Unfortunately, this is being done without robust research to identify the best cropping systems that could optimize the yield and returns from the concerned doubled up legume systems.

Previous research has indicated that growing two legumes in the same production unit has potential to improve soil fertility. Pigeon pea particularly of long duration type was the mostly used. In the current research the objective was to investigate the best spatial arrangement of intercropping groundnuts with medium duration pigeon pea varieties that have recently been recommended for production and are also suitable for non-traditional pigeon pea growing areas across the country. Six different treatments replicated three times were evaluated where groundnuts and pigeonpea were intercropped at varied plant population and spacing. Trials were conducted on-station at Chitala Research Station and at on-farm sites in Lilongwe, Kasungu and Salima districts. Randomised Complete Block Design (CRBD) was used. The trials were conducted from 2010-2011 to 2013-2014 seasons. Initial soil characterization was done. Agronomic data was collected in the course of trial implementation. The data collected were subjected to analysis of variance using Genstat Version 17. The results showed significant differences ($p < .001$ mostly) between locations for both groundnuts and pigeon pea biomass and grain yields. Cropping systems also had similar significant effects on biomass and grain yield of both groundnut and pigeon pea. All intercropping systems had higher total combined yield of the two crops compared to the sole crop yield of groundnut. This resulted in Land equivalent ratios of above 1.0 taking groundnut as the main crop. Other benefits included net returns for intercropping being higher compared to sole groundnut at on-station for all intercropping treatments and treatments 5 and 6 at on-farm sites. Benefit cost ratios were all above 1.0 indicating that the cropping systems were beneficial. However, the full population of both crops showed a benefit cost ratio of 0.8 which is less than the minimum 1.0 and therefore not recommended for farmer use. This could be due to groundnut yield suppression in the full population of both crops. Therefore, we only recommend two intercropping systems; full groundnut-half pigeon pea and 2/3 groundnut -1/3 pigeon pea alternate intercropping for farmer use.

Paper Number: 1193 (Poster Number: 137)

Grain Yields and Financial Returns from Hybrid Maize Intercropped with Cowpea Growth Types in Northern Ghana.

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Intercropping of open pollinate maize with cowpea is one of the major cereal-legume cropping systems in West Africa. Although several hybrid maize varieties are currently been promoted by the local and international seed companies, quantitative data is limited on grain yields and financial returns from intercropping the hybrid maize varieties with the different cowpea growth types used by farmers. The effect of inter-cropping erect (Songotra) and spreading (Sanzi) cowpea growth types with three hybrid (Pan53, Etubi, Mamaba) and an open-pollinated (Obatampa) maize varieties on grain yield and net returns was evaluated using a split-plot design with four replications in northern Ghana with cowpea growth type as main-plots and maize varieties as sub-plots. Grain yields, Land Equivalent Ratio and net returns to investment varied significantly among the treatments. The hybrid maize variety Pan 53 intercropped with the spreading and erect cowpeas recorded higher net returns of US\$ 514 and US\$ 501 respectively as against US\$ 488 for the sole maize. The results suggest that planting Pan 53 in pure stands or intercropped with the erect (Songotra) and spreading (Sanzi) cowpea types is more profitable than planting the Obatanpa alone or with the erect and spreading cowpea.

Paper Number: 1194 (Poster Number: 138)

Improving Rapid Assessment of Production Constraints for Common Bean: Results from a Biweekly Survey in Masaka, Uganda.

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Common bean (*Phaseolus vulgaris* L.) is the most important source of protein for human nutrition in Sub Saharan Africa, but yields are often limited due to soil infertility, foliar diseases, and weed interference. Inadequate dietary protein due to a lack of bean or other pulse grain consumption can result in stunting of young children. The objective of this study was to improve rapid assessment of biotic and abiotic constraints to common bean production by smallholder farmers in Masaka District, Uganda. Identifying and understanding important interactions of soil chemical and physical parameters with bean production is a necessary component for developing improved management solutions for bean farmers. The predominant soil types were Liddugavu (black Mollisols) and Limyufumyufu (red Oxisols). Prior to planting bean, soils were sampled at two depths, 0 to 15 and 15 to 30-cm, and analyzed for pH, nitrate, available P, K, Ca, Mg, extractable Al, and texture. Bean growth, development, nodulation, weed community, foliar diseases, and arthropod pests were monitored biweekly on 15 farms during the March-June 2014 rainy season in Masaka. Bean yield and yield components were determined at harvest. Several potentially highly important relationships previously not identified in Uganda include interactions among soil pH, bean nodulation, foliar disease level, weed density, and bean seed yield. These relationships include the following significant correlations: red nodule number per plant with plant disease ($r = -0.620$). Further analysis of this relationship provided the regression, Red nodule number/plant, $Y = 31.8 - 0.186x$, $r^2 = 0.385$, $P = 0.0137$, where x is the percentage of leaf area diseased. The leaf area with foliar disease, often seen as Angular leafspot and anthracnose diseases, explains nearly 40% of the variation in effective nodule number on bean.

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Nodule number on a per-plant basis explains nearly 40% of the variation in bean yield (bean yield, kg ha⁻¹, $Y = -1803 + 41.5x$, $r^2 = 0.397$, $P = 0.0209$ where x is the nodule number per plant). Another important relationship determined from soil analysis and biweekly bean monitoring was for weed density and soil pH at the 15-30 cm depth. Forty-five percent of the variation in average weed density was explained by soil pH (Total weed density, # m², $Y = -99 + 21.4x$, $r^2 = 0.450$; $P = 0.0121$, where x is pH at 15-30-cm depth. This relationship allows us to determine that at the higher soil pH values within our set of bean fields, the influence of weed management likely is more important to bean production than in soils with low, or very low, subsoil pH. We have shown that multiple interactions of biotic and abiotic stressors influence common bean productivity. Developing appropriate strategies to ameliorate these stressors requires additional research.

Paper Number: 1195 (Poster Number: 139)

Effect of Different Management Options on Yield of Climbing and Drought Tolerant Bush Beans in Different Soil Health Conditions.

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Effect of different management options on yield of climbing and drought tolerant bush beans in different soil health conditions.

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Bean crop is one of the most important legumes, mostly grown under traditional cropping systems. However severe droughts, associated with 'El Nino' weather events, have been experienced in Southern Africa, leading to decline in productivity. A participatory evaluation study, based on crop and soil fertility management, was undertaken in Dedza and Ntcheu districts, central Malawi during 2013/14 season. The study was aimed at demonstrating the effects of management options on yield of beans grown under different farming systems. Mother trials were laid out in split-plot design with the bean varieties as whole plots and management options as split plots, replicated three times. The management options were mono-cropping, intercropping with maize, use of manure, fertilizer, a combination of manure and fertilizer; and different staking options for climbing beans. Bean yield results showed significantly different responses to management options ($p = 0.01$) in both climbing and bush beans. The management option of using stick stakes and manure produced the highest mean yield of 1.961Mg ha⁻¹ whereas an option of using pigeon pea as stick stakes produced the least (0.741Mg ha⁻¹) in climbers. DC86-263 tended to be consistently high in management options which had NPK fertilizer as one of the treatment components. In bush bean, SER83 was responsive to manure application. The study demonstrated that different genotypes possessed unique attributes that enabled them to respond differently to different management options. We recommend further exploration of the genetic attributes in a wider genetic pool to come up with specific recommendations in legume-cereal intensification.

Key words: Cereal-legume cropping systems, climbing bean, management options, Africa RISING

Paper Number: 1196 (Poster Number: 140)

Adoption of Climate Smart Technologies in Cereal-Legume Systems in Northern Uganda: Constraints, Opportunities, and Trade-Offs.

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We examine adoption of climate smart agricultural practices, including reduced tillage, crop rotation, intercropping with legumes, use of improved seeds, manure, mulching, and cover cropping in mixed cereal-legume cropping systems. We ask the following research questions: 1) are these practices suitable to the cereal-legume cropping system and existing agro-ecologic conditions; 2) does adoption of these practices align with the important indicators that farmers' care about and does it consider gender disparities? We use data from 1070 intra-household gender surveys and 5 participatory workshops in Nwoya district, Uganda. We found that awareness ranged from 60 % for improved varieties to 10% for reduced tillage. The study further identified gendered differences relating to factors responsible for technology adoption between women and men. The three highest ranking considered factors by women were revealed as cost, lack of skills/knowledge and availability of inputs. Men indicated expected yield, capital and land availability. Cereals are mainly associated as male crops and legumes as women crops which affects practices adopted for the crops. Socioeconomic variables intrinsic to the study site are also shown to condition technology adoption. For example literacy, sex of the Household head, dependency ratio, farm size, land tenure, and distance to plot have a significant influence on adoption of improved varieties. Climate-smart technologies might however present trade-offs if adoption increases costs and demand for inputs especially when such inputs are not available. These results highlight opportunities and policy implications for targeting interventions.

Paper Number: 1197 (Poster Number: 141)

Climbing Beans: The Under Exploited Solution for Food Security in Rwanda.

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Common bean is the most important legume for nutrient security in Rwanda. At 4 - 5 t/ha climbing beans triple the bush types in grain yields, making them ideal for land intensified production. Although Rwanda is rich in adapted high yielding climbing beans, productivity of about 1t/ha is under-optimal. The biggest cause is the scarcity of staking materials. Poor or no staking cuts yields by 90%. A study was conducted to recommend farmer-acceptable staking innovations that limit use of wood stakes. 25m² plots of adapted climbing bean variety were staked with 2.0m-long wood poles at intervals of 0.5 to 2m within to give wood densities of 30%; 33.3%; 40% and 46% of the recommended 50,000 (100%) poles ha⁻¹ respectively. String trellises were dropped vertically from horizontal bars to fill the gaps. Unstaked and full wood-staked plots practices were checks. The trial was RCBD with three replications. It was planted over six locations and three seasons. Overall grain yield was least (180 kg ha⁻¹) and highest (6,200 kg ha⁻¹) for the respective control treatments. However, differences in means were statistically insignificant except for the unstaked treatment. Farmers ranked the 33.3% wood: 67.7% trellises combination highest despite the lower mean yields of 2,928 kg ha⁻¹ compared to 3,180 kg ha⁻¹ for the normal practice. Availability, labor, environmental concerns besides yield were the main determinants for the farmers' choices. It is compelling to focus on cost-effective staking options in order to exploit fully the already present genetic yield potential of climbing beans in Rwanda.

Paper Number: 1198 (Poster Number: 142)

Developing Conservation Agriculture Maize - Legume Systems for Smallholders in Niassa, Nampula e Zambezia - Mozambique.

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Developing Conservation Agriculture maize - legume systems for smallholders in Niassa, Nampula e Zambezia - Mozambique Chichongue, O. J.; Timo, F. A. And Murracama, M. V. Mozambique Agriculture Research Institute - IIAM Corresponding author: ochichongue@gmail.com Abstract Mozambique is witnessing severe degradation to its farmlands. Much of this degradation can be attributed to farming practices - ploughing that destroy the soil structure and degrade organic matter, burning or removing crop residues and mono-cropping. To change this situation, improved cereals and legume cropping systems design under better resource allocation and management conditions in Conservation Agriculture systems were tested across environments of Lichinga - Niassa, Mutuali - Nampula and Gurue - Zambezia. This was done through on-station experiments research aiming to identify best bet resource allocation strategies that can make cropping systems more attractive to poor resourced farmers involved in Conservation Agriculture. The response functions for maize intercropped with beans, soybean, cowpea, pigeon pea and groundnuts were determined for each research experiment. The objective of the study was to contribute to increased household food security of smallholder farmers in Niassa, Nampula and Zambezia and enhance their livelihoods. Two fertilizer treatments and five legume intercrop options were applied in a randomized complete block design (RCBD) with three replications. Due to different legume adaptations different intercropping options were used being in Lichinga maize were intercropped with beans, soybean and pigeon peas, and in Gurue maize were intercropped with beans and cowpeas while in Mutuali maize were intercropped with groundnuts, soybean, cowpea and pigeon peas. Results were subjected to ANOVA and the least significant differences (LSD) was used to separate the means. Results indicate significant differences among treatments with maize intercropped with common beans and in combination with application of 300 kg ha⁻¹ inorganic fertilizer increasing the maize yields followed by maize intercropped with cowpeas and in combination with 150 kg ha⁻¹ inorganic fertilizer in Gurue and Mutuali while in Lichinga maize intercropped with soybeans in combination with 150 kg ha⁻¹ inorganic fertilizer applications increasing maize yields. This study demonstrates that the intercropping legumes or combining with inorganic fertilizer has potential to address the low soil fertility problem in farmers' fields and raise yields of maize production. Keywords: Conservation Agriculture, Maize, legume, intercropping, yields.

Paper Number: 1199 (Poster Number: 143)

Legume Cropping Systems Diversification and Intensification for Soil Fertility Improvement and Family Nutritional Benefits.

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A study was carried out in 2011/2012 growing season in Kandeu and Manjawira Extension Planning Areas (EPAs) in Central Malawi to determine biomass yield and subsequent effects on soil fertility of the crop residues from various legume cropping systems. The experiments were laid out in a randomised complete block design with farms serving as replicates. In Kandeu EPA, there was significant difference ($p < 0.001$) in the dry weights of groundnut haulms in the sole and that intercropped with pigeonpea. There was significant difference ($p = 0.007$) in the dry weights of tops for soyabean in the sole and intercrop with pigeonpea. There was no significant difference in crop residues of groundnut in the sole crop and its intercrop with pigeonpea. The crop residues of pigeonpea in the sole crop, intercrop with groundnut and intercrop with cowpea were significantly different ($p < 0.001$) from each other. All the LER values were greater than 1 which means that intercropping of soyabean, groundnut, pigeonpea and cowpea were efficient in utilising resources than sole cropping. In both EPAs, LERs for pigeonpea intercropped with groundnut was higher, indicating yield advantage of the pigeonpea intercropped with groundnut. Crop residues from various legumes cropping systems have profound impact on soil fertility, as such, stakeholders should help intensify and scale out legume growing and incorporation of crop residues from various legume cropping systems (eg groundnuts and cowpea) by farmers, supplementing with low levels of inorganic fertiliser (24 kg N ha⁻¹) in order to help them harvest more maize grain yield.

Paper Number: 1200 (Poster Number: 144)

Participatory Evaluation of Improved Cowpea Varieties and Phosphorus Application in Northern Ghana.

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Abstract

Cowpea production in Ghana occurs mainly in the small-scale farming sector and is done with no agricultural input, such as phosphorus fertilisers resulting, not only in low grain yield but also nutrient mining of the poorly fertile soil, especially phosphorus. Constraints due to low soil fertility are exacerbated by the lack of adoption of improved cowpea genotypes coupled with poor agronomic practices. Though CSIR-SARI in collaboration with IITA have developed and released improved cowpea varieties and production technologies, smallholder farmers do not get access them. It is against this background that IITA in collaboration with CSIR-SARI and other partners through the USAID Cowpea Out-scaling Project are disseminating improved cowpea varieties together with production and processing technologies in 152 communities in northern Ghana. Widespread field demonstrations were established to showcase the superior performance of four improved cowpea varieties, Songotra, Padi-tuya, Zaayura and Apagbaala and their responses to phosphorus fertilizer. Treatments for each demonstration plot consisted of two improved cowpea varieties plus farmers' own variety and two P rates of 0 and 60 kg P₂O₅/ha. Results from the first year demonstrations indicated that the performance of the improved varieties were better than the farmers' variety by 40-64%, Padi-tuya gave the highest fodder yield in the Guinea savanna zone, whereas Songotra gave the greatest grain yield in the Sudan savanna. Besides, 60 kg P₂O₅/ha gave about 40% higher grain and fodder yields. These achievements will be disseminated to more cowpea farming communities during the project's implementing periods for increased the production and productivity.

Paper Number: 1201 (Poster Number: 145)

Comparison of the Indigenous Soil Classification System with the FAO and Soil Taxonomy Systems.

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Smallholder farmers in Uganda are yet to benefit from the soil scientific knowledge as farm level decision making is predominantly based on indigenous soil classification. This has led to poor extension service delivery manifesting as declining soil productivity. The objective of this study was to scientifically characterize the major indigenous soil types cropped to beans in Masaka district, Uganda. Farmer group discussions were held jointly to understand local classification of the soils in the study site.

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Soil samples were collected from three identified indigenous soils (Liduggavu (black), Limyufumyufu (reddish), and Luyinjayinja (gravelly)) differentiated by colour and stoniness. Field scientific characterization of soils of Kabonera sub-county was also carried out. Detailed soil analysis of the samples was done for scientific classification. Results showed Liduggavu soil superiority to Luyinjayinja and Limyufumyufu in terms of soil properties important for bean production (pH, exchangeable bases, CEC, ECEC, ECEC/clay, available P), the same way recognized by farmers. The characterization by FAO-UNESCO system identified five major soils as opposed to the three and two identified by the indigenous and FAO systems, respectively. The scientific classification grouped Liduggavu as Phaeosem; Limyufumyufu among Cambisol, Ferralsol, and Plinthosol while Luyinjayinja among Umbrisol, Cambisol and Ferralsol. These findings could help to communicate soil information between scientists and farmers necessary for transferring site specific soil management technologies among areas with the same attributes within the Buganda catena. However, more research is required to identify how farmers classify soils considering colour, stoniness and other criteria concurrently. Key words: common bean, indigenous knowledge, scientific classification, soil management

Paper Number: 1202 (Poster Number: 146)

Working with the Private Sector in Developing Farmers in South Africa - a MODEL That Works.

AS de Beer and JL Snijman, Agricultural Research Council*

BACKGROUND AND PROBLEM STATEMENT

Land redistribution is one of the most crucial and contentious focal points in South Africa's political arena. The efforts of government in post-Apartheid South Africa to increase and empower more black farmers were unsuccessful as 90% of farms distributed to black farmers are no longer productive. Challenges facing the new entrants are global competitiveness, low profitability as well as inadequate, ineffective and inefficient support and delivery systems from government to new farmers. Well established agricultural cooperatives, with the aim to solve market failures and to address distortions in the supply chain, are crucial in the support and sustainability of the commercial farmers in South Africa.

KEY FINDINGS

A partnership between the Department of Rural Development and Land Reform (DRDLR), the Agricultural Research Council (ARC) and Vrystaat Koöperasie Beperk (VKB, an agricultural cooperative,) was formed to assist four emerging farmers from the Makgolokoeng village (Harrismith, Free State), to plant 160 ha sunflower during the 2014/15 season. The aim of the project was to assist farmers to become independent and to compete in the commercial market. One farmer used his 40 ha subsidized sunflower as collateral and negotiated funding at VKB to plant an additional 54 ha dry beans. He in addition planted 100 ha soybean with the assistance of VKB from retained seed harvested the previous season.

SIGNIFICANCE OF THE FINDINGS

Emerging farmers can, in a very short timeframe, become sustainable commercial farmers in their own right over the long term with the right partners.

Paper Number: 1203 (Poster Number: 147)

The Case of Conservation Agriculture As a Climate Change Adaptation Measure for Small-Scale Farmers in Kalomo District, Zambia.

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The present study analysed the climate change adaptation driven CA practices being promoted in Kalomo district of southern Zambia and the associated challenges in their management and implementation. Conservation Agriculture (CA) is one of the climate change adaptation measures being promoted for small-scale farmers (SSFs) in Kalomo District of southern Zambia. CA is as much promoted for improving production and productivity for food security in rural areas, as it is promoted as an adaptation measure for sustainable agricultural production because of climate change. CA is especially promoted in areas that are prone to drought by encouraging precision placement of inputs and low labour demanding practices which respond to limited human and financial resources for SSFs. The results rely on semi structured interviews of extension officers and collaborating organisations in the implementation of CA as well as local literature. Among the three most applied CA principles, minimum tillage is the most practiced largely ahead of crop rotation and retention of crop residues. Ripping raises minimum tillage, it was found to be practiced on a larger scale compared to making planting basins. However, implementation and management of CA has been affected by some challenges. A number of challenges hinder the implementation of CA out of which planning, human resource development and financial resource constraints are the most threatening to efficient adaptation to climate change through CA. Further research is require to understand why crop rotation (especially legumes) is less practiced than compared to minimum tillage for for effective CA principles to effectively work.

Paper Number: 1204 (Poster Number: 148)

Enhancing the Release and Dissemination of Improved Drought Tolerant Cowpea Varieties in Nigeria.

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Cowpea (*Vigna unguiculata* (L.) Walp) is the most important food legume in West and Central Africa where it serves as a cheap source of vegetable protein and livestock fodder as well as a major contributor to the improvement and maintenance of soil fertility. In Nigeria, cowpea production takes place mainly in the dry savanna region. With the present climate change challenges, the importance of cowpea will increase significantly in this region where water stress deficit, poor soil fertility and parasitic weeds attack are frequently observed. Through multi-location trials conducted in 2012 and 2013, two promising high-yielding (over 2.0 t ha⁻¹ of grain), drought tolerant, Striga/Alectra tolerant, early-maturing cowpea varieties (IT07K-318-33 and IT07K-292-10) were identified. Participatory on-farm evaluation of these varieties revealed that IT07K-318-33 and IT07K-292-10 out-yielded the farmers' variety by 142 and 119%, respectively. Farmers showed preference for both varieties due to their early maturity, high yield, drought tolerance, high market value and good fodder quality. Consumers of cowpeas have different preferences for grain color; IT07K-318-33 (SAMPEA 16) is brown seeded while IT07K-292-10 (SAMPEA 17) is white seeded, thereby providing choice to both farmers and consumers. The brown seeds fetch higher market prices. The two varieties were approved for registration and release by the Nigerian Crop Varieties and Livestock Breeds Registration and Release Committee in June 2015 as it is obvious that farmers will be willing to adopt them. This committee is ensuring the availability of improved varieties to the farmers hence contributing to increased crop production.

Paper Number: 1205 (Poster Number: 149)

Effets Des Fertilisants Sur La Croissance Et Le Rendement De L'association Manioc Et Haricot Dans Les Conditions De Mushinga En Territoire De Walungu.

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Au Sud-Kivu, la faible fertilité des sols, les maladies et ravageurs des plantes et l'insécurité alimentaire constituent les défis majeurs de l'agriculture vivrière dans cette partie de la RD Congo. Cependant, la fertilisation du sol et l'utilisation des variétés améliorées contribueraient à relever ces défis qui ravagent la population de cette province, particulièrement dans le territoire de Walungu. Les résultats obtenus ont montré que le rendement en graines de haricot et le rendement en tubercules du manioc des variétés améliorées de ces cultures ont été influencées par la fertilisation des sols. Pour le haricot, la moyenne de 1296,2 kg.ha⁻¹ en saison A et celle de 1938,2 kg.ha⁻¹ en saison B a été obtenue grâce à la fertilisation des sols par la combinaison NPK+matière organique (MO) en comparaison des témoins de la saison A et B (382,81 kg.ha⁻¹ et 971,84 kg.ha⁻¹). Pour le manioc, la combinaison NPK+MO a influencé un accroissement du rendement avec une moyenne de 18,25 t.ha⁻¹ en comparaison du témoin 7,158 t.ha⁻¹. Ces résultats montrent que la fertilisation des sols et l'utilisation des variétés améliorées sont des opportunités pouvant accroître le rendement des cultures afin de lutter contre la malnutrition et l'attaque des maladies et ravageurs et permettre ainsi une bonne sécurité alimentaire d'où la poursuite de cette étude serait un atout dans l'autonomisation de la population rurale afin de lutter contre l'insécurité alimentaire et la pauvreté grâce à l'accroissement du rendement par la fertilisation des sols. Mots clés : Association manioc et haricot, engrais, rendement, Mushinga

Paper Number: 1206 (Poster Number: 150)

Climate Smart Crops for Food and Nutritional Security.

Obert Jiri and Paramu Mafongoya, University of KwaZulu Natal*

Leguminous crops are important in nutrition, particularly amongst resource poor people. Inclusion of legumes in the diet is important in control and prevention of various metabolic diseases such as colon cancer, diabetes mellitus and coronary heart disease. Legumes are sources of slow release dietary fibre (carbohydrates) and are rich in proteins (18 - 25%). In Africa, legumes are the cheapest sources of supplementary proteins, besides being sources of minerals and vitamins. Pulses represent one of the most important food categories that have been extensively used as staple foods to cover basic protein and energy needs throughout the history of humanity. In addition to their low lipid and high dietary fibre content, emerging evidence stresses the importance of pulses as carriers of several constituents of potential biological importance, including enzyme inhibitors, lectins, phytates, oxalates, polyphenols, saponins and phytosterols. Investigations in humans suggest that pulses may contribute to human health and wellbeing, mostly through prevention of coronary heart disease and possibly diabetes. The mechanisms responsible for this apparently protective role may include a favourable influence on blood lipids and glucose. The nutritional value of pulses, which are a key component of the traditional Mediterranean diet, is not generally recognized and is frequently under-appreciated. Southern Africa smallholder farmers continue to be the most affected by the challenges of climate change and variability. The variability of climate demands the use of a variety of agronomic strategies and crop choices. Traditional drought tolerant crops such as sorghum are often chosen when drought seasons are anticipated.

However, there are certain crops, originating elsewhere, that could help the smallholder farmers increase diversity of crops that can be grown in changed climates. One such crop is tepary bean (*Phaseolus acutifolius*). Trials were conducted to determine the growth of tepary bean on station and in the field. In the field it was compared to other commonly used legumes such as cowpea (*Vigna unguiculata*), Bambara nut (*Vigna subterranea*), ground nut (*Arachis hypogaea*) and pigeon pea (*Cajanus cajan*). Tepary bean matured in 54 days after planting, the earliest among all the legumes and producing a yield. A second experiment was done to determine the effects of inorganic fertilizer and rhizobium inoculation on the growth and grain yield of field grown tepary bean. This was conducted in a randomized complete block design with three replications at the University of Zimbabwe Crop Science fields. The treatments were: basal fertilizer (inorganic fertiliser, Compound D, 7:14:7 - N:P:K) with top dressing (ammonium nitrate (34.5%N)), basal fertilizer only, top dressing fertilizer only, rhizobium with top dressing fertilizer, rhizobium only and neither control with no rhizobium or any inorganic fertilizer (control). There were significant differences in biomass yield between the treatment with basal fertilizer + top dressing and the control ($P < 0.05$). Podding also showed significant differences between treatments ($P < 0.05$). On yield, results showed that a combination of ammonium nitrate with either compound D or rhizobium produced similar yield. Rhizobium with top dressing fertiliser had a mean yield of 0.57 t/ha whilst basal fertilizer with top dressing had 0.60 t/ha. Basing on these findings, we conclude that resource poor farmers, affected by drought effects of climate change, can use rhizobium for optimum production of tepary bean, in variable climate and drought seasons and still get a yield. This is crucial for food and nutritional security of vulnerable households affected by climate change and variability.

Paper Number: 1207 (Poster Number: 151)

Evaluation of the Performabce of Cowpea Cultivars at High Plant Population.

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Cowpea production in the northern Nigeria generally uses wide rows 75 cm apart similar to other grain crops. The low population resulting from this wide row spacing usually results in low yields of grain legume crops. Grain yields of the widely available stress-tolerant cowpea cultivars hardly go above 1.7 tons ha⁻¹ on farmers' fields, despite the enormous gain in genetic improvement over the past 3 decades. Field experiments were conducted in 2013-2014 in the Sudan and northern Guinea Savanna zones in northern Nigeria to evaluate the effects of plant population on cowpea performance. Four cowpea cultivars with contrasting maturity duration were planted in single, double and triple rows on ridges spaced 75 cm apart to achieve corresponding populations of 133,333, 266,666 and 399,999 plants ha⁻¹, respectively for comparison. Results show that plant populations of 266,666 and 399,999 plants ha⁻¹ gave higher crop performance in terms of light interception, biomass production and yield and yield components for all cowpea cultivars. Yield increases were related largely to increased pod and seed production. Although the medium maturing cultivars performed better than the early maturing cultivars, all the cultivars responded similarly to plant populations. Results show that the current population of 133,333 plants ha⁻¹ used by farmers is not optimum for cowpea production. Cowpea grain and fodder yields at population of 266,666 plants ha⁻¹ did not significantly differ from those at 399,999 plants ha⁻¹. It is recommended that farmers in the Nigeria savannas plant cowpea in double rows on ridges to achieve optimum yield

Paper Number: 1208 (Poster Number: 152)

Liming Requirements for Two Contrasting Soils in the LAKE Victoria Crescent.

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Smallholder bean farmers in Masaka and Rakai Districts in the Lake Victoria crescent commonly use three soils - Phaeozem (Black-Liduggavu), Cambisol (Red-Limyufumyufu) and Umbrisol (Stony-Luyinjayinja). Phaeozem presents no major limitations to bean production vis. pH related limitations, excessive Al and P availability. However, performance of beans in Umbrisol (pH 5.26, CEC 8.13) and Cambisol (pH 5.02, CEC 12.3) with pH below optimum range 5.8-6.5 is postulated to be negatively affected. This study was conducted to determine the Lime Requirement to adjust pH to 6.5 for bean production in two soils - Umbrisol and Cambisol using incubation and titration. We hypothesized that Cambisol with higher Exch. Al content 1.2 meq/100g would require equal amounts of lime with Umbrisol of lower Exch. Al content 0.8 meq/100g. The null hypothesis was rejected and alternative that Cambisol require more lime - 11.3 tonnes of Ca(OH)₂ per ha than Umbrisol (8.0 tonnes of Ca(OH)₂ per ha) to rise pH to 6.5. Similarly, targeting pH to 5.8, Cambisol and Umbrisol require 8.4 and 5.1 tonnes of Ca(OH)₂ per ha, respectively. Interestingly, the specific lime requirements to change one unit of pH in Cambisol was lower, 0.243 tonnes of Ca(OH)₂ per ha than for Umbrisol, 0.246 tonnes of Ca(OH)₂ per ha. The results highlight the importance of re-thinking fertilizer recommendations of NPK, DAP normally made without considering specific soil conditions and the need for scalable strategic land restoration and local actions (e.g. use of wood ash) to revitalize smallholder fields.

Keywords: bush beans, pH, Al toxicity, liming requirements, smallholder farmers.

Paper Number: 1209 (Poster Number: 153)

Effects of Cowpea Cultivar and Population Density on Yield and Yield Components of Cowpea [*Vigna unguiculata* (L.) Walp].

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A field experiment was conducted to determine the effect of cowpea cultivar and population density on yield and yield components of cowpea. The experiment was conducted at the teaching and research farm of the Federal University of Agriculture Makurdi (FUAM). Three intra-row spacing: 20, 40, and 60 cm at a constant inter-row spacing of 75cm, which gave plant population densities of approximately 66,667; 33, 333 and 22,222 plants/ha respectively were used. The result showed that intra-row spacing competition had no significant effect ($P \leq 0.05$) on grain yield and yield components traits measured. Similarly, cultivar x intra-row spacing interaction had no significant effect. However, there was highly significant effect of variety on all parameters measured. Although effect of intra-row spacing was not significant, there was a linear increase in yield as intra-row spacing increased for semi-indeterminate cultivar. On the other hand, grain yield decreased with increasing intra-row spacing for determinate cultivar. Intra-row spacing of 40 cm gave the highest yield for the semi-indeterminate cowpea cultivar, while intra-row spacing of 20 cm gave the highest yield for the determinate cowpea cultivars. Among the cultivars evaluated, UAM09-1056-2 a determinate and UAM09-1046-6-1, a semi-determinate cultivar gave the highest grain yield. This information will guide cowpea farmers in deciding on the appropriate intra-row spacing to adopt for semi-determinate and determinate cowpea cultivar for increased yield in the Guinea savanna.

Paper Number: 1210 (Poster Number: 154)

Starter Nitrogen Fertilization Effects on Yield and Profitability of Cowpea in Northern Ghana.

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Cowpea (*Vigna unguiculata* L.) production most West African countries is dominated by small-scale resource poor farmers who use very little soil amendments. Average cowpea grain is generally low due to low soil nitrogen (N) and phosphorus (P) levels. We tested the hypothesis that application of inorganic fertilizer, especially N can increase cowpea grain yields. The effect of three starter N levels N (0, 15, 30 kg/ha) on grain and fodder yields and profitability of two improved cowpea varieties ((Apagbaala: grain type and Padituya: dual purpose) was evaluated in a 2 x 3 factorial treatment arrangements with three replication over a 2-year period. Application of starter N increased grain yield by 39.4%, fodder yield by 41.5%, and gross return by US\$ 89 (107.9%) in Guinea savanna agro-ecological zone. In Sudan savanna, starter N fertilizer increased grain yield by 42.5%, fodder yield by 30.4%, and gross return by US\$ 107.2 (115%). Averagely, application of N fertilizer beyond 15 kg/ha did not show significant response to grain, fodder and gross return. Padituya cultivar responded significantly to grain yield (28.8%), fodder yield (31.6%), and gross return (US\$ 158.7, 21%) across the two agro-ecological zones. Padituya cultivar with application of 15 kg/ha starter N may be used for improved grain and fodder yield production with better gross returns in northern savanna zone of Ghana.

Paper Number: 1211 (Poster Number: 155)

Extent of Adopting Improved Legume Varieties in Northern and Eastern ZONE of Tanzania.

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Extent of Adopting Improved Legume Varieties in Northern and Eastern Zones of Tanzania

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ABSTRACT

The low use of improved legume varieties in Tanzania is one of the factors limiting agricultural production. The gap between actual yield and estimated potential yields of legume is also a result of the inadequate use of improved legume varieties. This paper analyzed the factors that influence the extent (amount of land allocated to improved legume varieties) of adopting improved legume varieties in Northern and Eastern zones of Tanzania. The sample of 200 households collected by Adoption Pathway Project in 2013 using household level survey was used. Heckman Two stage sample selection model using Stata software was used to determine factors influencing the extent of adopting improved legume varieties. The results indicated that, respondents who spent more than seven years in school and those who have communication and transportation assets were more likely to adopt improved legume varieties at $p \leq 0.05$, and respondent's income and zone they belong as a source of variation also significantly influence the extent of adopting improved legume varieties at $p \leq 0.1$.

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It was concluded that farmers education, income, zones and access to transportation and communication assets were the major factors influencing extent of adopting improved legume varieties. And it was recommended that government and other development organization should create favorable environment like subsidization of the farming technologies, improvement of rural infrastructures and strengthening farmers knowledge on modern agriculture production.

Key words: Technology, Adoption, Legume(s), Tanzania

Paper Number: 1212 (Poster Number: 156)

Alternative Methods of Staking Climbing Beans in Northern Province of Rwanda: Sustainable Intensification of Legume Technologies.

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One of the major challenges encountered by small farmers in climbing bean production is lack of staking materials. This in turn hinders the adoption of the technology despite it leads to better yields. Most small holder farmers lack enough land to grow trees such as eucalyptus which is a good source of wooden poles used for staking climbing beans varieties. N2Africa and partners from the districts of Musanze, Gakenke and Burera of the northern province of Rwanda have been trying different methods of staking climbing bean to see which ones can be a substitute to the expensive and scarce wooden poles. The substitute materials tried included maize stalks and sisal/plastic strings. In the demonstration plots, wooden poles, maize straw and strings were tried side by side. Results obtained after three seasons have confirmed that the strings are the most promising method to replace the wooden stakes. Maize straw was found to be too weak and short (less than 2m height) and it could not withstand the weight of bean pods during the maturation stage. It also could not allow full growth of tall climber varieties. Initially, sisal strings were used, but they have been replaced by plastic strings which are very cheap and easily accessible at local markets. They also last long and can be used in several seasons compared to wood and sisal. Farmers who hosted the demo plots affirmed also that plastic strings were favorable for ventilation through the biomass of growing plants, which prevent rats to hide and eat the pods.

Paper Number: 1213 (Poster Number: 157)

Are Grain Legumes Displacing Maize, Increasing Food Security and Improving Livelihoods in Eastern Kenya?

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Are Grain Legumes Displacing Maize, Increasing Food Security and Improving Livelihoods in Eastern Kenya? Wafula K. Carolyn¹, Lukorito Cromwel² and Esilaba. Anthony³ 1Kenya Agricultural & Livestock Research Organization (KALRO), The Food Crops Research Centre, P.O Box 340-90100 Machakos, Kenya. E-mail: ckhalayi@yahoo.com. 2 University of Nairobi Department of Meteorological Sciences P. O. Box 29053, Nairobi, Kenya 3Kenya Agricultural & Livestock Research Organization (KALRO) Headquarters, P.O Box 57800-00200 Nairobi, Kenya Abstract Premised on the idea that maize is a staple food in majority of Sub-Saharan African countries, over 10 million Kenyan people are food insecure with majority of them living on relief food and have limited choices of other food stuffs. In the drive towards food security, agriculture as an industry has traditionally been diversified. One important aspect of this is the growing of more than one crop type by household farmers mostly for subsistence. A survey was carried out among 112 Kenyan smallholder farmers in Kathonzweni sub-county of Eastern Kenya in the year 2014 to assess food production practices. Random sampling technique was used to select respondents; collected data was analyzed using SPSS software. Results indicate that grain legumes (green grams, cowpeas, beans and pigeon peas) could be displacing maize with (84.5%) of farmers growing green grams, (80%) cowpeas, (48.2%) pigeon peas compared to (16.4%) maize. Majority of the farmers practiced intercropping, yields of the individual crops per unit production of green grams and cowpeas seemed to be the best performing and highly ranked by the farmers as the most preferred food crops (23.9%, 22.5%). Most of the farmers sold farm produce to pay school fees, domestic expenses, medical needs and boosting their income. The challenges of climate change, pests and diseases, inadequate seed and farm inputs were the major constraints affecting agricultural production in the study areas. Policy maker should therefore take advantage of these factors that boost food security, increase household income positively and formulate policies appropriately.

Key word: Food security, cowpeas, green grams, pigeon peas, maize, smallholder

Paper Number: 1214 (Poster Number: 158)

From Small Seed Packages to Tons of Grain: Success Stories from Farmers in Rwanda.

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N2Africa, a research to development oriented project led by Wageningen University, started its activities in Rwanda from February 2010. It focused on promoting technologies to increase production of grain legumes, with emphasis on common bean and soybean. The project initiated campaigns to create awareness and disseminate these technologies with thousands of participating farmers receiving small packages of seeds, fertilizer and inoculants. The campaigns were organized in 5 districts of Rwanda in collaboration with respective local partners. The project first started by conducting on-farm trials of these technologies, from research, under the supervision of project researchers. Field days were held and the farming communities invited to evaluate the technologies being tested and select the most suitable ones to their farming systems. The selected technologies were further demonstrated in plots partly managed by a selected farmer group or cooperative. Surrounding farmers also received small packs of the selected technologies e.g. variety of common bean or soybean to test in their own farm. The dissemination packages were distributed to thousands of new farmers each planting season. They also received a field book with technical information on how to use the material received, to collect data and give feedback to the project on how the technologies performed in their farm. The high performing technologies were quickly picked and adopted by farmers after adapting them to their local conditions. Success stories collected from the over 13 project actions sites confirmed that the farming community had widely adopted N2Africa technologies. Examples picked from twenty two thousand former project beneficiaries convey high impact of these technologies on individual lives.

Paper Number: 1215 (Poster Number: 159)

Scientific Animations without Borders: An Assessment in Benin of Learning Gains from Educational Animations in a Local Language As Compared to Traditional Extension.

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Integrated Pest Management (IPM) often includes an educational component for farmers on techniques known to be highly effective in insect control. This is clearly the case in IPM associated with the control of the pests of cowpea and beans, where pest management solutions exist in the academic literature. However, one of the challenges of disseminating these technologies to farmers in Africa is that many of them speak diverse languages, their often live in remote areas, many are low literate learners and there is a need for low-cost scalable educational content to disseminate these. To this end, Scientific Animations Without Borders creates educational animations on a diversity of topics of importance to these communities, including animations on IPM techniques for the control of legume pests. We compared the effectiveness of educational animations with traditional extension presentations in terms of increasing the knowledge of rural populations in Benin on agricultural and healthcare related topics. We tested the hypothesis that viewers would experience the same level of learning gains as attending a traditional extension presentation. Animations placed into the local language of the participants and traditional extension approaches were tested to determine learning gains. Semi-structured pre and post training interviews, translated into local languages, were used to collect primary data from 240 small-scale farmers in 8 villages of Benin. The results indicated that both videos and traditional extension demonstrations were effective in transmitting knowledge, however, overall animations were more effective in fostering detailed knowledge retention among participants. Furthermore participants preferred the animated videos.

Paper Number: 1216 (Poster Number: 160)

An Option Value That Measures Impact of Germplasm Conservation: Using Adoption Estimates of Improved Cowpea Varieties in Nigeria.

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Plant Genetic Resources (PGR) management is an integral part of crop improvement for production, diffusion and retention of new varieties of agricultural crops. Unfortunately, previous impact studies on improved cowpea varieties (ICV) neglected PGR conservation to analyse the effects on farmers' livelihood and returns on research investments. These two parameters drive donors' continuous funding, most especially the outcome of ICV adoption on farmers' income. IITA detains the largest proportion of cowpea germplasm in the world.

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Therefore, we used the potential impact framework of Local Average Treatment Effect (LATE) with instrumental variable approach and economic surplus models to assess the economic and social impact of cowpea germplasm conservation at IITA. The results showed that 37,000 units of cowpea accessions from IITA genebank were received by scientists who were affiliated to 49 research and academic institutions in Nigeria. A large proportion of accessions were used by IITA's scientists and their partners from national agricultural research institute (NARI) to develop breeders' lines. Furthermore, an adoption study conducted in Kano State, the largest cowpea producing State in Nigeria and the DNA test conducted on adopted cowpea samples linked five ICV to the conserved germplasms at IITA's genebank. The adopters of ICV increased their cowpea productivity by 254% on 58% of cowpea farmlands cultivated in 2012. They also increased their per capita income by N64.19 ($P=0.0000$). The Net Present Value (NPV) and Internal rate of return (IRR) of 31 years investments on cowpea germplasm conservation and improvement were \$3,630,625,337 and 54% respectively. A total number of 884,241 farmers would have been lifted out of poverty over the same period of time. Applying the recommendation from literature of 50:50 sharing rule, this paper argues that attributed benefits to germplasm conservation alone are substantial and they justify increased investment on exploration, conservation and improvement of cowpea germplasm.

Key words: cowpea-germplasm, conservation, breeding, biotechnology, adoption, impacts, return of investment, Nigeria.

Paper Number: 1217 (Poster Number: 161)

Préférences Des Utilisateurs Des Produits De Traitement Et De Conservation Du Niébé Et Le Consentement à Payer Pour Les Solutions Alternatives Dans Le Département Du Couffo (Sud-Ouest Bénin).

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Problématique: La culture du niébé constitue un important potentiel dans la sécurité alimentaire et la réduction de la pauvreté. Elle est la légumineuse la plus attaquée par les ravageurs. Les producteurs utilisent les méthodes de lutte chimique alors qu'il existe des méthodes alternatives. L'étude vise à apprécier le consentement à payer des producteurs pour l'utilisation des solutions alternatives aux produits chimiques dans le contrôle des ravageurs et leurs perceptions sur les extraits botaniques proposés. Approche et Résultats : 120 producteurs de niébé ont été enquêtés. Les statistiques descriptives ont été utilisées pour l'analyse des données. L'étude a montré que 5,8 % des producteurs approuvent fortement payer une somme moyenne de 125 FCFA et un maximale de 250F CFA de plus pour toutes innovations qui réduiraient la contamination du niébé aux champs ou au stockage même s'il n'occasionne pas une augmentation de leurs revenus contre 10 % des producteurs qui désapprouvent fortement. 50 % des répondants consentent à payer une somme moyenne de 300 FCFA de plus pour toutes innovations qui réduiraient la contamination du niébé aux champs et pendant le stockage et augmenterait le rendement. Conclusion: Les producteurs perçoivent les extraits botaniques comme disponibles, moins chers et non toxiques. Par contre, la préparation est difficile, les actions sont lentes, le traitement est élevé (5 à 6 fois) et spécifique à certains ravageurs et le rendement est parfois faible. La mise sur pied des systèmes de solutions alternatives aux produits chimiques est possible et contribuera à la sauvegarde de l'environnement.

Paper Number: 1218 (Poster Number: 162)

Mining for Gold: Large Scale Data Management and Analysis of on-Farm Legume Trials.

Joost van Heerwaarden and Marcel Lubbers, Wageningen University*

On-farm experimentation is key to determining the performance of agricultural technologies under realistic conditions and management. When such trials are implemented by diverse project partners, obtaining, handling and analysing the resulting data can become a challenge. N2Africa is a large, multi-partner "research-in-development" project that aims to improve legume productivity for small scale farmers. One of the core principles of the project is that data is analysed quickly to provide feedback for the subsequent season. To achieve this, we have developed a data collection and management system that enables automated handling and analysis of on-farm trial data. Data is collected by project partners using standard forms on electronic tablets and all data, including GPS coordinates and images, are uploaded to a central server at the end of each trial. Data is then compiled into a project database and transferred for downloadable form that is suitable for analysis. Automated, basic analyses are performed and reports are generated and shared with partners. We demonstrate the power of this approach by presenting a combined analysis of yields and response to inputs across several crops, locations and countries using data collected and processed in 2014 and 2015.

Paper Number: 1219 (Poster Number: 163)

Farmers' Agronomic and Social Evaluation of Cowpea Technologies in the Guinea Savanna Zones of Ghana.

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Cowpea plays an important role in household food and income security in smallholders farming systems in the Guinea Savanna zones of Ghana. Yields are however low, hardly exceeding 600 kg per hectare. Within the framework of N2Africa project, several technologies aimed at raising the grain yields beyond 600 kg per hectare have been introduced to farmers. These technologies include the introduction of superior cowpea genotypes, use of phosphorus fertilizers, optimum plant spacing and other good agricultural practices. We evaluated these technologies together with smallholder farmers in the two savanna agro-ecologies in the three Northern Regions of Ghana. Cowpea grain yield under farmers' traditional practices ranged from 710 kg ha⁻¹ in the Upper East Region to 820 kg ha⁻¹ in the Northern region; grain yield under phosphorus fertilized plots ranged from 1020 kg ha⁻¹ in the Upper West Region to 1200 kg ha⁻¹ in the Northern Region. Phosphorus fertilizer application resulted in 34%, 46% and 69% increase in grain yield over the traditional farmers' practices in the Upper West, Northern and Upper East Regions respectively. There were no significant differences among the various cowpea varieties evaluated with farmers although the improved varieties always yielded higher than the local varieties. Farmers' criteria for ranking cowpea included maturity period, yield and seed size. IT97k-499-35 was ranked by the farmers as the most preferred cowpea variety due to its white seed type, early maturity and good market value. While farmers appreciated the increase in grain yield due to phosphorus fertilizer application, access to the input still remains a challenge.

Paper Number: 1220 (Poster Number: 164)

Participatory Action Research to Improve Farmer Decision Making in Integrated Soil Fertility Management in Mozambique.

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Common bean (*Phaseolus vulgaris* L.) and maize are important food security and cash crops for smallholder farmers in study communities in Gurué district in northern Mozambique (baseline survey, 2014). Yields for beans under rainfed conditions range from 0.4 to 0.8 ton/ha. This low yield for beans is due to poor soil fertility, water stress, pest and disease and lack of information on best agronomic practices. To address these challenges, project researchers are partnering with agricultural colleges, development organizations, and extension services. Participatory research and promotion activities are strengthening capacity to increase bean productivity. Key activities undertaken include: on farm testing of ISFM technologies that are targeted to identified soil nutrient deficiencies, field days, development of decision support aids for farmers, and promotion of 'best bet' technologies, including use of mobile phones (audio and video information). Enhancing researchers' capabilities with GIS and remote sensing is helping the project team to integrate local knowledge and technical information for clustering soils types, assessing their suitability to bean production. Socio-economic analyses of baseline household survey data are identifying challenges and opportunities for improving productivity and marketing in maize-bean production systems. This will enable the project team to develop decision support aids that reflect producers' priorities and constraints in concert with soil and cropping system characteristics for improved bean production.

Paper Number: 1221 (Poster Number: 165)

Growth Performance of Weaner Rabbits Fed Cowpea Based Rations As Protein Source.

Edmore Masama, Zimbabwe Open University*

The study was conducted to investigate the effect of varying levels of cowpea in maize diets on the performance of weaner rabbits. Twenty-four mongrel rabbits of both sexes, 4 - 5 weeks old with an average weight of 624g were randomly distributed to four dietary treatments with six rabbits per treatment for 42 days. The four diets were formulated using cow peas which had been dehulled and fermented for 24 hours as a way of reducing antinutritional factors. The control Treatment 1 contained 18% CP from soybean while Treatments 2, 3 and 4 had 10% CP, 15% CP and 20% CP respectively based on cowpea. Clean cool water was offered ad libitum and feed offered and eaten was recorded daily. The rabbits were weighed weekly to determine body weight changes. Rabbits fed on diet 2 had significantly ($p < 0.05$) lower feed intake compared to other diets. Rabbits fed on diet 1 gained significantly ($p < 0.05$) more weight (500g) than rabbits fed on diet 2 (180g) after 5 weeks. The results indicate that cowpea can be used safely as a protein source in rabbit diets at inclusion level of up to 20% CP provided it is well processed.

Paper Number: 1222 (Poster Number: 166)

Adoption of Integrated Soil Fertility Management in Central Uganda: The Influence Perceived Practice Characteristics and Socio-Economic Factors.

Naboth Bwambale, Robert E Mazur and Eric A Abbott, Iowa State University*

Declining soil fertility, exacerbated by continuous cultivation of land, poverty and limited access to productive assets, is an important factor limiting land productivity among smallholders in Uganda. Integrated soil fertility management (ISFM) practices that involve a combination of organic and mineral fertilizers, and other improved farming practices such as planting legumes and diversified crop rotations within cropping systems have been promoted but their adoption rate has remained low. Based on in-depth interviews with 27 smallholders in Masaka and Rakai Districts, this study examined how perceived practice characteristics and socioeconomic factors affect adoption of ISFM practices and technologies. Significant attributes are relative advantage of a practice (locally available materials, multifunctionality of the practice and relatively low cost of investment), ability to observe success of the practice before adoption (from fellow smallholders or through experimentation), and compatibility with existing farm operations and less complexity (less labor intensiveness and smaller package sizes). The influence of these attributes varies among farmers due to heterogeneity in household wealth, land tenure, social networks, access to input-produce markets and extension services. Extension agents and farmer-to-farmer interactions are the most trusted information sources for ISFM. To facilitate adoption of ISFM, applied research should focus on: promoting practices performing multiple functions within farming systems; using iterative learning approaches that encourage interaction between farmers, extension specialists, and researchers; and conducting benefit-cost analyses to facilitate development of flexible and adaptable ISFM measures that are cognizant of heterogeneity in farmers' resource endowments - particularly land size, livestock ownership and income.

Paper Number: 1223 (Poster Number: 167)

Evaluation of Drought Tolerant Common Bean Varieties for Adaptation, Yield and Acceptability in the Drought Prone Areas of Burundi.

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In Burundi; common beans are important grain legume as staple crop and major source of protein, energy and micronutrients (Fe, Zn) for smallholder farmers. Common beans are produced in all agro ecological zones ranging from lowland (770 masl) to highland (2,200 masl) conditions. However, due to the climate change and variability, Bugesera and Moso, formerly considered as the main regions for common bean production, are experiencing shortage of rains. Introduction and evaluation of drought tolerant bean varieties was identified to contribute to increase bean production under drought conditions. Four drought varieties were received from CIAT namely KATB1, KATB9, KATX56 and KATX69. They were tested for adaptability, yield and acceptability tests in drought prone area of Moso, Imbo and Bugesera regions. The adaptability tests started in 2006 by on-station and multi-location evaluation followed with participatory evaluation approach with bean farmers within the drought prone areas of Burundi (Moso and Bugesera). All the four bean varieties were appreciated for their early maturing period (60 to 65 days after planting) and high yielding potential (800 to 1,400 kg ha⁻¹ on farm and station conditions, respectively). These varieties have been largely adopted to producing bean seed and grain for both home consumption and income generation particularly by farmers in the drought prone areas of Burundi.

Paper Number: 1224 (Poster Number: 168)

Agricultural Technology Adoption and Nutrition: Assessing the Impacts of Improved Chickpea Varieties in Ethiopia.

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Abstract

The potential to secure adequate food consumption among rural households can be achieved by developing and adapting improved quality, environmentally friendly technologies such as the improved Chickpea varieties. Several studies have shown that the adoption of these improved Chickpea varieties has significantly increased the income of adopters. However, increase in income does not always translate to improve nutrition status among households. This paper examines the linkage between adoption of improved Chickpea varieties and the consumption of food nutrients among Ethiopia farming households. The paper uses the Tropical Legumes II panel data to estimate protein and calories income elasticities. It takes into account the quality effects and other unobservable. The direct approach in which information on food purchased and produced by households is used to estimate a model of demand which is then converted into nutrient elasticities.

Food composition tables are used to convert quantity of food purchased (consumption and wastage), to calories and protein contents equivalence and then the resulting nutritional index is evaluated for food utilization. Household expenditure (instead of income) on food quantity will be used in the computation of nutrition index. Choice of calories and protein for this evaluation is because for the poor, major deficiencies were accompanied by caloric and sometimes protein deficiencies. Preliminary analysis shows increasing food consumption among adopting households. Results from the estimation will be presented and analytic issues will be discussed including quality aspects.

Paper Number: 1225 (Poster Number: 169)

Use of Animated Videos through Mobile Phones to Enhance Agricultural Knowledge and Adoption Among Bean Farmers in Gúruè District, Mozambique.

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While hermetic storage of beans and cowpeas in sealed containers effectively reduces losses due to bruchids (weevils) and other insects, adoption of this method has been slow in much of Africa. In some cases, this is due to a lack of triple bags, jerry cans, or other technologies that can prevent oxygen from passing through the material. However, in most cases it is due to farmers' lack of knowledge and training. With increasing use of storage chemicals which can have negative impacts from eating, handling or inhaling the vapors, it is important that farmers learn chemical-free methods that are safer and more effective. In Mozambique, only 13% of farmers were reached by agricultural extension agents. This study tested whether animated video messages about hermetic storage in a plastic jerry can delivered via smartphones can effectively supplement extension training or be effective in stand-alone training. In Zambézia Province, 314 bean-growing farmers were assigned randomly to one of three experimental treatments: (1) extension demonstration only; (2) smartphone animation only; (3) extension demonstration and animation. The three treatment groups did not differ significantly from each other in a priori knowledge about the storage method, though women knew significantly less than men. After training, all groups significantly increased their knowledge, but the extension only treatment showed the least learning. Nearly all farmers expressed their intention to use this technique. Agricultural messages designed as animations delivered via smartphones results learning as well or better than traditional extension presentation. Women learned more from the animations than men, suggesting that animations may be effective in overcoming gender barriers in agricultural learning.

Paper Number: 1226 (Poster Number: 170)

Can Cowpea Farming be Smart Enough Under Higher Climate Variability?

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Can Cowpea Farming Be Smart Enough Under Higher Climate Variability? Abstract Climate is changing. In Sub-Saharan Africa, the predicted challenges for the smallholder farming systems will likely be the greatest of all time: increased frequency and intensity of daily rainfall, false start and early cessation of the rainy season, decreasing trend in diurnal temperature and increasing number of hot nights and warm days, water-logging, decreasing arable lands and micro-nutrients depletion etc. How can climate variability be translated into farming options that will spur rain-fed cowpea build resilience? The objective of this research is to provide advisory on the best fitting agro-ecological practices in a likely drought, extreme dry and wet spells, heatwaves and their likely combinations at 2-to-3-month lead time of crop growth cycle. Two cowpea genotypes were calibrated within the CROPGRO model and tested across a spectrum of climate stressors and crop management practices to identify potential adaptation measures to higher climate variability. The crop model calibration and validation process is based on a combination of field and survey experiments and the climate information is taken from historical data and sub-seasonal to seasonal forecasts. The ability of the crop model to reproduce medium- and short-cycle cultivars and their specific characteristics such as drought resistance was proven. The sensitivity simulations provided a range of smart practices against some possible weather/climate hazards in the region. This crop-climate modeling design provides roadmaps that translate local climate information into farming options in order to alleviate the negative impacts of climate extremes on rain-fed cowpea. Keywords: cowpea genotypes, climate extremes, farming roadmaps, crop-climate modeling.

Paper Number: 1227 (Poster Number: 171)

Enhanced Dissemination of FOOD Legumes Based Technologies for Increased Production in Dowa, Ntcheu and Rumphi Districts, Malawi.

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PROBLEM STATEMENT In Malawi most farmers depend on local legume seed sources that are characterized by low germination rate and poor yield. A lot of improved legume varieties and associated management practices have been developed and released. However these have not been effectively promoted among smallholder farmers, leading to low awareness and adoption. The low outreach has been contributed by limited interactive learning amongst farmers due to among other things as high staff to farmer ratio. The project is therefore promoting the use of certified legume (bean, groundnuts, soybeans, cowpeas and pigeon peas) seed and associated improved management practices through extension methods that promote interactive learning. Ninety three (93) lead farmers were trained and supported to host on farm demonstration (fig, 1). The technologies promoted included; use of improved legume varieties, tillage practices, crop rotation and use of fertilizer. **FINDINGS** Over 2,325 farmers have expressed interest to plant improved legume varieties in the 2015/2016 season. The trained lead farmers filled the gap that was created due to shortage of extension workers. The twelve field days were well patronized resulting into increased awareness of the improved legume technologies through interactive learning. **Figure 1 SIGNIFICANCE OF THE FINDINGS** Appropriate extension methods on interactive learning is key to increasing legume productivity for both cash and subsistence. Lead farmers with knowledge on the content of technologies being demonstrated are able to adequately explain during field days, leading to increased adoption of the improved legume varieties. 1

Paper Number: 1228 (Poster Number: 172)

Identification of Criteria Linked with Farmers' Acceptability of Improved Cowpeas Via Farmers' Participatory Varietal Selection in Burkina Faso.

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Cowpea (*Vigna unguiculata*) is an important crop for promoting the food security, livelihood, and cash income of farmers. Various improved cowpea varieties have been developed and released by the breeding programs in many national agricultural research systems in Sub-Saharan African countries. However, the reports on farmers' selection criteria and farmers' acceptability of improved cowpea varieties are still limited. Further, these acceptability are sometimes complicated by the fact that the selection criteria employed by farmers vary by region and/or gender within the same country. Thus, in order to better understand the preferences and selection criteria employed by farmers, farmer participatory varietal selection (FPVS) activities were undertaken in northern and southern Burkina Faso. A total of 10 cowpea genotypes with different characteristics were planted and demonstrated to farmers. A total of 1,911 farmers (62%: male, 38%: female) invited to the demonstration fields established in 5 villages. The survey revealed that the most important criteria for farmers were grain yield and early maturity. Interestingly, the preference of farmers for seed size was quite different in the north and south. Although the farmers have generally preferred larger seed size, there was an upper limitation in their acceptable size. This study also clarified regional and gender differences among farmers' preferences. These findings immediately not only contributed to the dissemination of the effective improved varieties in Burkina Faso but also indicated that regional/gender differences of preferences for cowpea varieties should be taken into the account for further breeding of the improved varieties with better acceptability.

Paper Number: 1229 (Poster Number: 173)

Planning Investment Programs in Agriculture Research & Development.

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During the past decade, investments in crop research in Sub Saharan Africa have been on an increase. Growth has been marked by an increase in public investments from governments, donor sourced investments in NARS, country based research entities and investments by IARCs under the umbrella of CGIAR. As such, there has been considerable pressure for agriculture research for development to reorient their plans towards effectiveness and results. The Results Based management (RBM) is a planning and management system first introduced in the Pan African Bean Research Alliance (PABRA) in 2010. Mainly for its benefits in demonstrating outcomes of research for development programs on a causal dimension of sequenced outcomes in a theory of change. We have documented the RBM experiences of the PABRA program over a period of five years. We reviewed 30 documents consisting of; funding proposal documents, annual reports, minutes, work plans, program databases, and experiences of program staff. We established challenges and successes in the application of the RBM for improved decision making, planning and organization learning, and for accountability to public investors, and prioritizing budget allocations.

Reviews point to improved policy coherence and planning in largely dispersed programs, enhanced impact monitoring, higher R&D outcome ratings and greater investor support. These are useful lessons applicable to grain legume initiatives. Future research could address adaptations for pairing RBM with other planning models providing alternative ways for planning in complex research and development contexts across sectors.

Paper Number: 1230 (Poster Number: 174)

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

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Thirty Farmer's field schools were established from 2013 to 2014 in south central of Niger with 600 producers in the departments of Guidan Roudji, Madarounfa, Magaria, Tanout and district of Droum. It has been experienced twelve (12) technologies including seven improved cowpea varieties, application of organic manure, mineral fertilizer NPK (15-15-15) and the combination of both for the recovery of soil fertility and use of neem seeds aqueous extracts and chemicals for crop protection. For the varietal test, the highest average yield of 1074 kg / ha was obtained with IT90K 372-1-2 improved variety over the two years. Genotypes IT99K 573-1-1; IT89KD 374-57; TN 5-78; IT97 499-38 K; K VX 30-309-6G gave an average yield between 649 and 812 kg / ha. The organic and mineral fertilizer combination led to an increase of 323% average yield compared to control. The neem seeds aqueous extracts reduced the infestations of *Clavigralla tomentosicollis* (Stal.), *Aphis craccivora* Koch, *Maruca vitrata* Geyer and an increase the cowpea yield by 258%. The cropping system combined with the improved varieties, normal plant density, pest control, organic and mineral fertilizer application can increase cowpea yield by 113%.

Keywords: Cowpea, *Vigna unguiculata*, Niger, pesticide, fertilizer, local variety, improved variety, biopesticides, IPM, F.P, yield.

Paper Number: 1231 (Poster Number: 175)

On-Farm Evaluation and Farmers' Perception of Improved Cowpea Varieties in Ghana.

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Cowpea (*Vigna unguiculata* L. Walp) is an important source of dietary protein and minerals and constitutes an essential part of farming systems in most African countries. In Ghana about 95% of the cowpea produced in the country is produced by smallholder farmers. However, only 10% of these smallholder farmers use improved technologies including improved varieties. Dissemination of improved technologies is one of major challenges in cowpea production. In order to address this challenge, a participatory varietal selection approach was used to develop new varieties. Four improved cowpea varieties, a local check and a farmer's variety were evaluated on farmers' fields in twelve locations in Ghana. The objective of this study was to elicit on whether farmers would adopt these varieties and to facilitate dissemination through demonstrations and field days. Farmers were allowed to assess these lines alongside their own variety. All four improved lines performed better than the farmer's varieties in term of yields. The results also suggested that farmers preferred the improved varieties over their own varieties, indicating that the four cowpea lines could be released for use by farmers.

Paper Number: 1232 (Poster Number: 176)

Legume Intercropping and Household Food Security in Zambia.

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In addition to improving soil fertility and crop productivity, legumes may impart significant benefits to human health, nutrition, and food security. According to the FAO, farmers may store legumes for long periods of time with no loss of nutritional benefit, which allows farmers to choose to consume or sell their legumes between harvests. In this research we explore the effects of legume intercropping on smallholder farm household food security in rural Zambia. Specifically, we hypothesize that households who intercrop legumes have greater levels of food security, as measured by the Months of Adequate Household Food Provisioning (MAHFP) indicator. Using the nationally representative Rural Agricultural Livelihoods Survey (RALS) conducted in 2012 in Zambia, we analyze the effect of legume intercropping on MAHFP. Preliminary results indicate that legume intercropping has a negative effect on food security, although this may be due to endogeneity in the model. Future analysis will explore propensity score matching and instrumental variables techniques to address endogeneity. Additionally, when the RALS 2015 data are available, we will use panel data techniques such as fixed effects in an attempt to control for time invariant unobserved heterogeneity. After addressing the endogeneity issue, we may find positive effects of legume intercropping on food security. The findings of this research may influence policy decisions in Zambia.

Paper/Poster Abstracts

Given that the current input subsidy program encourages the cultivation of maize, research indicating positive effects of legume intercropping may lead the government to introduce an intercropping requirement for recipients of subsidy packages.

Paper Number: 1233 (Poster Number: 177)

Towards Increasing Cowpea Production and Productivity in Northern Ghana.

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Abstract

The USAID Feed the Future's (FtF) quest to achieve her goals of reducing poverty and malnutrition by moving innovations out of laboratories or research stations and to smallholder farms culminated into the USAID Cowpea Project under the auspices of the International Institute of Tropical Agriculture (IITA). The three project focuses on scaling out of best-bet cowpea production technologies, such as, quality seed of improved cowpea varieties, integrated pest management, appropriate crop management practices and improved postharvest storage. The project launch in Tamale was followed by regional inception workshops organized by the Ministry of Food and Agriculture at the regional capitals to sensitize the policy makers and popularize the project through distribution of good quality seeds. In collaboration with Ministry of Food and Agriculture, demonstrations of best-bet cowpea production technologies and community seed productions were carried out in 152 communities of northern Ghana. These demonstrations were used to train the farmers and the community-based organizations in cowpea production techniques. In all, 390kg and 1822kg of breeder and foundation seeds respectively were distributed/sold to the seed growers/companies and the farmers in 2015. These were planted 15.6 and 72.88ha respectively across the three regions. About 10 and 55tons of foundation and certified seeds respectively would be produced for the 2016 cropping season. A total of about 5,000 farmers had been reported as benefitting from the project with 1:1 male to female ratio in the first year. It is expected that production and dissemination of quality seeds will increase the cultivation of cowpea in northern Ghana.

Paper Number: 1234 (Poster Number: 178)

Private Sector LED Agricultural Innovation Platforms: Lessons in Formation and Operationalization.

*Richard Miiro*¹*, *Moses Makooma Tenywa²*, *Robert Mazur³*, *Onesimus Semalulu⁴*, *Jafali Matege¹*, *Stewart Kyebogola¹* and *PROSSY KYOMUHENDO⁵*, (1)Makerere University, (2)College of Agricultural and Environmental Sciences, Makerere University, Kampala, (3)Iowa State University, (4)National Agricultural Research Laboratories (NARL) Kawanda, (5)MAKERERE UNIVERSITY

PRIVATE SECTOR LED AGRICULTURAL INNOVATION PLATFORMS: LESSONS IN FORMATION AND OPERATIONALIZATION Richard Miiro*, Moses Tenywa, Robert Mazur, Onesmus Semalulu, Jafali Matege, Stewart Kyebogola, and Prossy Kyomuwendu * Presenting author rfmiro@gmail.com Department of Extension & Innovation Studies, School of Agricultural Sciences, Makerere University, P.O. Box, 7062, Kampala +256-772-378185 Uganda Topical Category: Technology Dissemination and Impact Assessment Abstract Statement of the problem or hypothesis: Multi-stakeholder innovation platforms have gained ground in Sub Saharan Africa as a way of solving complex problems of agricultural value chains, albeit they have been mainly researcher led and controlled. A Legume Innovations Lab project focused on improving soil fertility for bean productivity enhancement in South Uganda, has catalyzed the formation of alternative private sector led multi-stakeholder platforms. Findings: Key actors include large scale bean trader, a bean seed buyer, small scale bean traders, farm input suppliers, micro-finance, USAID projects, two major non-governmental organizations, media, and public institutions of extension, commerce, cooperatives, research and Universities. Three Universities including two from the USA are involved and creating R&D opportunities for the platform. Formative experiences of the platform have involved 8 farmer-managed trials using integrated soil fertility management for enhancing bean productivity established in the second season of 2015, attracted over 200 farmers willing to grow bean seed in 2016. Significance: The significance of the platform for grain legumes research is in the understanding of lessons of how R&D activities promoted through a private sector led multi-stakeholder and value chain linked platforms work. Research opportunities in social, extension, governance and biophysical, farmers' views, benefits and challenges are shared as well as institutional and governance processes, and mechanisms for co-financing of production of bean seed and grain on contract basis.

Paper Number: 1235 (Poster Number: 179)

Introducing CA Demonstration Plots As an Extension Tool in Different Communities in South Africa.

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BACKGROUND AND PROBLEM STATEMENT

The lack of crop diversity and crop rotation as a practise of more sustainable production systems is a reality on many developing farming units in South Africa. In this context, the correct crop and cultivar choice as well as sound farming practices can make a significant contribution to crop diversification and crop rotation practices, which in turn can lower the risk, and increase the sustainability of farming units. The use of demonstration plots are common practise to illustrate scientifically proven practices and of great value in emerging farming communities to conceptualise new practises in a short timeframe.

KEY FINDINGS

Demonstration plots illustrating different CA principles were established at 14 sites of emerging farming communities in four provinces of South Africa. This was a joint effort between the Agricultural Research Council (ARC), Grain South Africa (GSA) and the different communities. The purpose of the demonstrations was to introduce emerging farmers to various production practices such as available alternative crops, crop rotation, residue retention and minimum tillage. A simple two year rotation system with maize including commercial cultivars as well as Water Efficient Maize for Africa (WEMA) and Improved Maize for African Soils (IMAS) varieties and different legume crops, adapted to the different sites, were planted at each site. Participation by communities were ensured by means of Innovation Platforms (IP). Farmer's field days were held to enhance training.

SIGNIFICANCE OF THE FINDINGS

Hands on participation through demonstration plots enabled communities to make meaningful comparisons and created excellent opportunities to experience scientifically proven practices. This contributed immensely to unlock the untapped potential of farmers in rural communities and to enhance food security through sound and sustainable farming practices.

Paper Number: 1236 (Poster Number: 180)

Price-Quality Relationships in Fodder Trading in Niger with Special Regards to Comparisons of Cowpea and Groundnut Haulms with Concentrates and Collected Shrubs and Grasses.

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A total of 635 fodder samples were collected over the course of the year 2014 to 2015 from two rural and two urban fodder markets in Niger. Feed and fodders samples were analyzed by Near Infrared Spectroscopy for nitrogen, neutral (NDF) and acid (ADF) detergent fiber, acid detergent lignin (ADL), in vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) content. Data were statistically analyzed by ANOVA and regression analysis. Feed and fodder were grouped into concentrates, mainly agro byproducts such as brans, legume haulms such as cowpea and groundnut haulms, green forages such as grasses collected from bushland and finally stover from sorghum and pearl millet. Price-wise cowpea and groundnut haulms came right after the concentrates and commanded about 78% (cowpea haulm) and 57% (groundnut haulm) of the average price of concentrates, generally confirming the high monetary value of legume haulms. Feed and fodder prices were significantly ($P < 0.05$) correlated with key laboratory fodder quality traits such as NDF ($r = -0.78$), nitrogen ($r = 0.64$), ME ($r = 0.58$) and IVOMD ($r = 0.56$). However, feed and fodder pricing was not entirely satisfactorily explained by laboratory fodder quality traits and other factors for such as perceptions of farmers, traders and livestock keepers seem to play an important role. More work is required to understand these perceptions, including action research build around scientific alternative least cost fattening diets.

Paper Number: 1237 (Poster Number: 181)

Bambara Nut Production, Consumption and Commercialization in Northern Mozambique.

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Abstract

Bambara nut is an important for food security and nutrition crop, but most farmers grow only a small area. This project sought to develop a bambara nut business model, linking producers, traders, suppliers and processors. A semi-structured questionnaire was used to interview 384 smallholder farmers, agrodealers, traders and processors in seven sites about inputs suppliers, production, perceptions, opinions, beliefs and attitudes on bambara nut. Legume traders in 10 markets were interviewed. In almost households, farmers produce and consume bambara nut fresh (March-May) and dried (June-October), either alone or with cassava, maize, sorghum or rice. In the villages, there are no improved varieties; the main sources of seed are prior harvest, neighbours, relatives, and local markets. Farmer groups (9) were interested in producing bambara nut for consumption and selling. In some areas, traders are interested in commercialization of bambara nut. However, in several areas, no trader was interested. Support for promotion of bambara nut could include providing inputs to farmers, developing contracts, connecting farmers to external markets (Tanzania), and promoting consumption of bambara nut in towns.

Key words: Production, Consumption and Commercialization

Paper Number: 1238 (Poster Number: 182)

Assessment of Legume Utilization Among Smallholder Farmers in the Democratic Republic of Congo (DRC), Kenya, Rwanda and Nigeria.

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A study was conducted to investigate the level of legume processing and utilisation among smallholder households in target countries to identify gaps and areas of intervention. Focus Group Discussions (FGD) were conducted in each of the target countries namely Rwanda, Kenya, Democratic Republic of Congo (DRC) and Nigeria. Information collected included knowledge of the crops grown in each community and their order of importance, legumes grown and importance, form of utilization of legumes, legume products currently being made, processing methods and equipment used. The discussion also explored problems encountered during processing, storage and quality management as well as problems encountered with processing equipment. The current frequency of legume consumption as well as proportion of diet of community members that is legume was also explored. Results showed that respondents in Kenya, Rwanda and DRC ranked beans and soybeans as most important legumes while respondents in Nigeria also ranked groundnut as legume of importance in addition to cowpea and soybeans. In addition, respondents highlighted poor knowledge of processing and utilization of other legumes apart from soya beans; rudimentary post-harvest processing equipment which adversely affect production efficiency and are labour intensive and time consuming; need to introduce and train farmers on other methods of producing soy milk; development and introduction of appropriate packaging material for soy milk as constraints to processing and utilization of legumes. Results from this study identify areas for intervention to promote soybean processing and utilization at the household level for improved nutrition and income generation.

Paper Number: 1239 (Poster Number: 183)

Acceptability of Cowpea Fortified Maize Porridge By Under Five Children and Their Mothers.

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Environmental Enteropathy is a gut inflammatory condition reported in 20% to 75% children under 5 years of age from rural sub-Saharan Africa associated with malabsorption of nutrients leading to stunting. Probiotics or antibiotics have been unsuccessful in managing the problem. Evidence suggests that a diet enriched in legumes like cowpea decreases the markers of EE in children. Cowpea (*Vigna unguiculata*) is a source of protein with significant anti-inflammatory effects that can mitigate effects of EE. Though highly consumed in Africa, cowpea is not extensively utilized in complementary foods especially in southern Africa. This study evaluated the sensory acceptability of cowpea fortified maize porridge among children aged 6 to 36 months and their mothers. Cowpea flour was processed using roasting, boiling and dehulling (soaking 22h) before milling. Microbial safety was ascertained by testing for Salmonella and E. coli, markers of hygiene.

Sensory acceptability was determined by babies between 6 and 36 months and their mothers upon signing consent forms. Results showed that the three cowpea fortified porridges were acceptable to both mothers and children when rated using a 5 - point hedonic scale with no significant differences between observed feeding, at home feeding and caregiver liking ($P > 0.05$). The outcome of this study has informed a clinical trial on EE using legume feeding underway in Malawi. In addition, these results will promote the growth and utilization of cowpeas in weaning foods in Malawi thereby promoting it as a cash crop for the rural masses.

Paper Number: 1240 (Poster Number: 184)

Nutritive Value of Cowpeas As a Ruminant Livestock Feed.

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Nutritive value of cowpeas as a ruminant livestock feed JJ Baloyi^{1*}, H Hamudikuwanda², NT Ngongoni³ and S. Katsande⁴ ¹Department of Animal Science, School of Agriculture, University of Venda, Thohoyadou, 0950. South Africa ²ABS TCM Rwanda Ltd, Rwanda Dairy Competitiveness Program II, P.O Box 569, Kigali, Rwanda ³Faculty of Agriculture, Zimbabwe Open University, Harare, Zimbabwe ⁴Department of Paraclinical studies, Faculty of Veterinary Sciences, University of Zimbabwe *Corresponding author: Cell +27 73 102 4942; Email: joseph.baloyi@univen.ac.za Abstract In southern Africa, ruminantss livestock largely feed on natural pasture grass (veld) and forages. During some seasons, limited supply and poor quality of natural pasture grass and forages constrain ruminant production. One way to improve the quality and quantity of feed available to ruminants is to introduce legume forages such as cowpeas in natural or sown pasture. Given the potential value of cowpea forage in ruminant feeding, the objective of this study was to evaluate the nutritive value of cowpea (*Vigna unguiculata*, L.Walp) forage in ruminant feeding. In this regard, chemical composition, ruminal degradability and intestinal digestibility of dry matter, and protein (nitrogen and amino acids contents) were determined. Pure stands of cowpea were grown and sampled from Henderson Research Station, Mazowe, Zimbabwe. At sampling, all plants within a 0.5 m² quadrant, placed at random in the cowpea stand, were cut at 10 cm above the ground. During individual samplings, plants from four quadrant replicates were cut (harvested). Samples were harvested at the pre-anthesis, anthesis and post-anthesis stages of maturity. They were then partitioned into leaves and stems and were also analysed for contents of dry matter (DM), ash, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). The samples were also analysed for rumen in sacco degradability, and true protein intestinal digestibility. Amino acid composition of the samples was determined using high performance liquid chromatography. The DM content of the cowpea forage was ? while total ash content ranged from 72 g/kg DM in stems to 143 g/kg DM in the leaf. Crude protein content ranged from 89.2 to 209 g/kg DM Leaves had a CP content that was almost double of that in stems. The CP content increased up to flowering stage and then declined after flowering. The NDF and ADF contents of stems harvested from pre-anthesis to post-anthesis were consistently higher ($P < 0.01$) than those for the same growth stages in the leaves. The degradability constants a, b, a+b and c for the DM and the Effective degradability (ED) estimates at rumen fractional outflow rates of 0.02 and 0.05 per hour of cowpea were not affected ($P > 0.05$) by stage of maturity. However, the potential degradability (a+b) values decreased by 5% from pre-anthesis to post-anthesis. The degradation rate constants for nitrogen were not affected ($P > 0.05$) by stage of maturity of the forage. There was an interaction ($P < 0.01$) between the feed type and the pre-rumen incubation time on the amount of disappearance of Neutral detergent insoluble nitrogen (NDIN), Total amino acid (TAA), Indispensable amino acids (IAA) and Dispensable amino acid (DAA) post- ruminally. The residues pre-incubated at 48 h in the rumen had lower ($P < 0.01$) digestibility than those pre-incubated at 48h. In conclusion, cowpeas has high protein and total ash contents but DM and protein digestibility and degradability decline with maturity. As a result, provided it is harvested before post-anthesis maturity stage, cowpea forage can be a good potential protein and feed source for ruminant livestock. In addition, contrary to standard, fixed CP degradabilities used for conventional individual feeds, the change in cowpea forage CP degradability at different maturity stages indicates that fixed values for CP degradability could be inappropriate for cowpea forages.

Paper Number: 1241 (Poster Number: 185)

Effect of Processing on Nutritional Composition and Cooking Time of Selected Bambara Groundnut (*Vigna Subterrenea L. Verde*) Types.

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Paper Number: 1242 (Poster Number: 186)

Edits-Cowpea: Strategic Approach to Develop Value-Added Cowpea Varieties with Higher Food and Nutrition Qualities.

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Cowpea [*Vigna unguiculata* (L.) Walp.], an important regional crop in West Africa, retains tremendous potential to improve nutritional balance and livelihoods in the region. In addition to improving quantity in the production, more attention would be placed on quality to promote utilization and consumption, and further production of the crop through value-addition. Seeking possible strategies for the value-addition, we initiated EDITS-Cowpea project to generate the necessary scientific information and tools that would promote the value-addition of cowpea in West Africa. We obtained the following scientific outputs and information through the project activities: (1) Documented genetic diversity in various quality-related traits (i.e. crude protein, micronutrients, oligosaccharides, phytic acid etc.); (2) Confirmed low associations among physical and nutritional properties of grain, and basic agronomic traits indicating possible introgression of favorable traits using rich genetic resources; (3) Identified promising genetic materials with specific agronomic and quality-related traits; (4) Identified several key observable quality-related traits and additional effect of variety name that influence market price based on the market survey conducted in northern and southeastern Nigeria; (5) Developed tools/protocols for grain quality (seed size & color, protein content, sweetness, cooking time etc.) to evaluate the samples from breeding programs and market survey. These findings suggest possible value-addition to the crop through breeding activities with identified key quality-related traits and genetic materials and developed tools. We consider that these outputs will link the primal elements needed for grain quality improvement, and facilitate the development of breeding strategies for value-added cowpea.

Paper Number: 1243 (Poster Number: 187)

Effects of Blanching Time/Temperature Combination Coupled with Solar-Drying on the Nutritional and Microbial Quality of Cowpeas Leaves in Kenya.

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Effects of blanching time/temperature combination coupled with solar-drying on the nutritional and microbial quality of cowpeas leaves in Kenya

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ABSTRACT

The abundance of cowpea leaves during the rainy seasons and the traditional preservation systems leads to post-harvest losses on nutrients. There is need to reduce these losses by seeking an alternative relatively cheaper, hygienic and locally adaptable preservation method. Solar drying could be a useful dehydration option. No sufficient data is available on a suitable combination of solar drying and blanching protocol for preservation of cowpeas in Kenya. This study investigated the effects of controlled blanching time/temperature combination coupled with solar-drying on the nutritional and microbial load of cowpeas in finding a suitable preservation technique. The cowpea leaves (*Vigna unguiculata*) is commonly consumed in Kenya. Two blanching conditions (80oC/10 min and at 90oC/5 minutes) were tested. Blanching at 100oC for 30 min, followed by open sun-drying was used as control, while conventional oven drying of the cowpea was used as standard for comparison. Greatest nutrient loss was observed for cowpea leaves that were blanched at 100oC for 30 min, then sun-dried. Most nutrients were retained at 80oC/10 min compared to those retained at 90oC/5 min. Microbial load (5.3-5.6 cfu/g) was significantly lower for solar dried ILVs ($p < 0.05$) blanched at 90oC/5 min. This indicates that blanching at 80oC/10 min followed by solar drying is a potential option to be used as a local preservation technique for cowpea in Kenya.

Key words: Cowpea, blanching, solar-drying, open sun-drying, dehydration.

Paper Number: 1244 (Poster Number: 188)

Consumer Choice of Dry Common Beans in Lilongwe City.

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Grain legumes play a critical role in smallholder's economic growth in Malawi. Despite their importance, empirical research has mostly concentrated on yield enhancement and factors affecting common bean production. Considering the potential of grain legumes to reducing hunger and malnutrition, this paper aims at identifying factors shaping demand for and consumption of dry common bean from a consumer's perspective. Understanding and addressing these factors has potential to increase common bean consumption by enabling breeders to breed common beans with attributes mostly preferred by consumers. The study employed both qualitative and quantitative approaches to assess various aspects of household common bean consumption from primary data collected in Lilongwe City. The study results suggest that socio-economic factors such as household size, education, and area of residence play an important role in a household's decision to consume common beans and quantities consumed. Various product attributes such as grain size, gravy quality, and cooking also influenced a household's decision to consume common beans. While common beans are a rich source of dietary protein, results also suggest that an increase in household incomes is associated with a reduction of common bean consumption. Even though common beans are important for food and nutrition security, the study results show that an additional child under 5 years in the household was associated with a reduction in quantity of common beans consumed. It is therefore important for future research to understand the dynamics of household common bean consumption and under-five nutrition.

Paper Number: 1245 (Poster Number: 189)

Participatory Evaluation of Dry Bean Products to Enhance Nutritional Status for Small Holders through Increased Utilization.

*Charity Wangari Gathambiri** and *Juster Kathure Gitonga*, Kenya Agriculture and Livestock Research Organization

Dry beans provide a rich source of dietary fiber of about 14-19%. Value addition of dry bean products diversifies utilization of these crops; hence improve the nutritional status of the community and rapidly expanding market for dry beans. Sensory evaluation is a tool that is used to describe properties of a product and determine its acceptability by consumers. Sensory analysis uses human senses to consistently measure such food characteristics as taste, texture, smell, and appearance. Some of the sensory attributes that may influence acceptance of cooked beans are general visual, appearance, texture and flavor (taste and aroma). A study was carried out to participatory evaluate acceptability of value added dry bean products. The products were dry bean chapatti, dry bean porridge and dry bean cake. About 96% of the respondents most liked the taste of the cake while 74% of the respondents most liked the chapatti. More than 70% of the respondents most liked the taste of the three products. The texture of all the three products was most liked by majority of the respondents (63-93). In overall acceptability of the products majority of the respondents most liked (96%) the cake, followed by porridge (78%) and then chapatti (67%). The results indicated that majority of the respondents rated the quality attributes of dry bean porridge, cake and chapatti as most liked. None of the product quality attributes was disliked by the respondents. Value addition of dry beans enhances its consumption and hence improves nutritional status of the community.

Key words: Dry beans, value addition, sensory evaluation

Paper Number: 1246 (Poster Number: 190)

Assessment of Chemical and Antinutritional Properties of Complementary Meal Prepared from Blends of Banana and African Yam Bean.

*Grace Oluwakemi Babarinde** and *Tolulope Precious Oyebiyi*, Ladoke Akintola University of Technology

Gross intake of energy staple foods in some parts of Africa has led to protein energy malnutrition (PEM) and household food and nutrition insecurity. Supplementation of carbohydrate with protein rich food is important in reducing PEM. African Yam Bean (AYB) (*Sphenostylis stenocarpa*) is an underutilized legume that is rich in protein and trace minerals. In order to increase its potential, complementary food was produced from blends of banana and AYB in ratios 90:10, 80:20, 70:30 and 100:0 was used as control. Proximate, vitamins, minerals and anti-nutrient composition of the complementary food were determined. Sensory attributes were determined using 9-point hedonic scale by judge of panelists. The results of the proximate analysis are: protein (5.41-11.26%), fat (1.97-4.56%), carbohydrate (72.71-79.89%), fiber (0.39-0.57%), ash (3.23-3.97%) and moisture (7.86-8.20%). Vitamin A ranged from 0.93 to 2.91 g/100 g. Protein and Vitamin A increased with increase in AYB inclusion. There was no significant difference in Vitamin B1, calcium and magnesium of all samples. Oxalate (8.73-4.38%) decreased with increase in AYB inclusion. Tannin values ranged from 17.09-26.73 mg/100 g and phytate from 11.59-46.77 mg/100 g.

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The sensory evaluation shows that the product was widely accepted and samples 100:0 and 90:10 banana: AYB were mostly preferred in terms of colour, texture, taste, flavour, appearance and general acceptability. The inclusion of AYB increased the protein content of the complementary meal. This will help in reducing PEM. Supplementation of banana with AYB is a good approach in improving household food and nutrition security in developing countries.

Keywords: African yam bean, banana, complementary food, food and nutrition security

Paper Number: 1247 (Poster Number: 191)

Proximate Composition, Hydration Behavior and Cooking Characteristics of Six Cowpea (*Vigna unguiculata* L. Walp.) Varieties in Ghana.

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Most staple food sources in Africa are cereals, roots and tuber crops and food legumes. While the cereals, roots and tuber crops supply mainly carbohydrates, the grain legumes add value to the diets by supplying protein, fat and essential micronutrients. Malnutrition resulting from poor diets remains a challenge in most African countries. Cowpea is an important source of vegetable protein and minerals that could be used in food formulations. It can be eaten as green leaves, immature pods or as mature dry grains. In Ghana, varietal development and release requires a comprehensive assessment of the nutritive value and functional properties for both food and non-food utilization. In this study, we determined the proximate composition, hydration behavior and cooking characteristics of four elite cowpea lines proposed for release and two previously released varieties as checks. The four elite lines were (CRI-(8)-1, CRI-11(9)-2, CRI-11(9)-3 and CRI-11(9)-5. The previously released varieties were Asomdwee and Hewale. Percent crude protein, moisture, and carbohydrate ranged between 22.41 - 25.46, 7.41 - 11.37, and 57.61 - 63.17 % respectively. Total energy ranged between 337.54 and 350.98 kcal. Cooking time, Volume Expansion Ratio, Gruel solid loss, hydration capacity and Index, ranged between 25.00 - 42.50 min, 2.07 - 2.29, 0.27 - 0.78 g, 0.12 - 0.17 g/seed and 0.83 - 1.01 respectively. The results indicate that these cowpeas could serve as good template and potential functional ingredient for a lot of aqueous and non-aqueous food formulations both in food and non-food utilization.

Paper Number: 1248 (Poster Number: 192)

Development and Evaluation of Complementary Foods from Teff Fortified with Soybean and Orange-Fleshed Sweet Potato.

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Beyond the sixth month of an infant's life, the mother's breast milk can no longer meet the nutrient and energy requirements that are required for proper physical growth, intellectual development and resistance to diseases. Thus, during this critical period, the infant must be supplied with appropriately formulated and processed complementary foods. Unfortunately, most infants and children in Ethiopia lack the access to such a food and rather rely on foods that are of low nutrient and energy density. This research aimed at formulating and processing of nutrient- and energy-dense complementary foods from red teff fortified with soybean and orange-fleshed sweet potato in the ratio of 70:20:10, respectively, by using extrusion cooking. Promising results that meet nutrient and energy requirements of infants were obtained. Protein and energy values of the extruded complementary foods ranged from 10.42 to 17.90g/100g and 360.03 to 392.41Kcal/100g, respectively. Significantly high values of β -carotene were obtained: 4.21 to 5.22 mg/100g. Values for calcium, iron, zinc and phosphorus were 185.32 to 231, 16.95 to 19.07, 4.58 to 6.11 and 357.52 to 492.09mg/100g, respectively. There was a significant reduction in the phytate content of the treatments ranging from 68.21 to 92.60%. The results showed that the formulation is able to tackle both protein-energy malnutrition and micronutrient malnutrition among infants in Ethiopia. The study revealed that energy- and nutrient-dense complementary foods can be processed from a combination of red teff, soybean and orange-fleshed sweet potato which are all underutilized. Soybean incorporation improved protein and fat contents of the complementary foods while its optimizations remains to be further investigated.

Paper Number: 1249 (Poster Number: 193)

Development of a Simple Tool for the Identification of Easy and Hard-to-Cook Common Beans (*Phaseolus vulgaris*).

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Despite the known nutritional and functional benefits of beans, development of the hard-to-cook (HTC) defect is a major impediment to greater consumption of beans in Kenya. Identification of easy-to-cook (ETC) and HTC beans is thus of great importance to bean breeders, processors and consumers. However, identification of the ETC and HTC beans is difficult where the appropriate equipment and analytical methods are unavailable. The objective of this study was therefore to establish a simple analytical tool for identifying ETC and HTC beans. This study investigated the effect of different storage conditions (temperature and RH) and time on the physical, chemical and cooking quality changes of beans. Storage caused an increase in the cooking time, a measure of HTC defect. This was accompanied by a decrease in the phytates, swelling and hydration coefficients and an increase in leached solutes, electrical conductivity and tannins. Correlation tests showed that hydration coefficient, swelling coefficient and phytates were negatively correlated with cooking time while leached solutes, electrical conductivity and tannins were positively correlated with cooking time. Finger pressing and instrumental (cutting) tests were used to determine the cooking time of beans and were very highly correlated. The simpler finger pressing test can be used to accurately determine the cooking time of beans. Where equipment for analysis of cooking quality of beans are unavailable, finger pressing test can detect deterioration of stored beans. At the research laboratory level, the parameters affected during storage can measure cooking quality important in breeding and handling of grain legumes.

Paper Number: 1250 (Poster Number: 194)

Modeling of Drying Characteristics of Solar-Dried Fermented Locust Beans (*Parkia biglobosa*).

Goodluck Ehis Odiase, Ayoola Patrick Olalusi and Oluwaseun Yetunde Agbola, FEDERAL UNIVERSITY OF TECHNOLOGY AKURE, ONDO STATE, NIGERIA*

The processing of locust bean into food condiment has been done manually which makes it tedious for large scale production. The daily demand for this condiment is on the rise because of its nutritive and medicinal benefits. Hence the need for standard drying techniques that will best retain the desired nutrients. In this study, fermented locust beans was dried under the indirect solar dryer as well as the sun, and the data obtained were evaluated using existing drying models. 100g of fermented locust beans was placed in the indirect solar dryer and in the direct sun. Weight loss was monitored at intervals of 30 minutes. The drying data were fitted into 13 thin layer drying models. The best model was the one which gave highest R², and least chi-square (X²) and RMSE values. Proximate analysis was also carried to determine quality. Results showed that drying took place majorly at falling rate period. The samples also dried from an initial moisture content of 62% to an equilibrium moisture content of 14.50 and 12.81% (wet basis) for solar and sun dried samples. It took longer time to dry in the direct sun. The protein, crude fat and crude fibre contents were higher in the solar-dried sample. The Modified Henderson and Pabis model best described the drying behaviour for both drying methods. Dried fermented locust can be processed into powder, and cubes after proper drying and this will increase the shelf life and accessibility

Paper Number: 1251 (Poster Number: 195)

Water Absorption RATE and Proximate Analysis of Three Varieties of Legumes.

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In Nigeria, some postharvest operations of legumes particularly dehulling are done wet. Therefore, adequate knowledge of water absorption rate and proximate composition of legumes are needed for the processing and determination of nutritional values of the crops. To this end, the water absorption rate and proximate composition of three varieties of legumes: soyabeans, cowpea and pigeon pea were studied. All the legumes were conditioned to 10.2% (wet basis) moisture content. Water-holding capacity was determined by standard methods which take into account weight differences before and after soaking. The proximate compositions of samples were also determined for moisture, crude fat, fibre, protein and ash content. The volume of water absorbed by the seeds increased with the soaking time, but the samples presented distinct behaviours. Despite the distinct behaviour of the samples, water-absorbing capacities were statistically similar. The chemical composition and water holding capacity of three samples were compared. The result showed that pigeon pea had the highest composition of ash (9.93±0.28%) and fat content (3.68±0.04%). Cowpea had the highest value of protein (31.60±0.40%) and carbohydrate (50.90±0.80%). Cowpea had the highest water holding capacity (36.9%) after 5 hours of soaking and the soybean had the least water holding (28.6%). Soybean and Pigeon pea are good functional foods for nutrition and utilization while the cowpea is a good source of low fat food as it contained the least of the fat content amongst the three samples.

Paper Number: 1252 (Poster Number: 196)

Nutrient Composition and Consumption Pattern of Underutilized Pulses in Three Districts of Southern Malawi.

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Different types of pulses are grown in Malawi but are still being underutilized and these include: pigeon peas, bambara groundnuts, cowpeas, hyacinth beans, lima beans, mung beans, chick peas and velvet beans. The aim of the study was to determine the consumption patterns of underutilized pulses in Zomba, Phalombe and Chiradzulu districts of southern Malawi. In addition and factors affecting consumption were also explored. The consumption frequency of the pulses at household level was low, such that 40 to 70% of the respondents had consumed either of the pulse more than three to six months from time of survey (May 2014). Pulses were mostly consumed in months when they were harvested for 2 to 3 months. There was little variation in preparation of the pulses and these included as stewed[1], snack[2] and chipere[3]. Factors affecting production of the pulse and leading to poor consumption included lack of extension services and market, unavailability of reliable seed system and inadequate land hold size. Protein content for unprocessed pulses ranged from 15.3±0.7g (bambara groundnuts) to 22.49±1.19g (velvet beans) and after processing using common processing methods for the pulses significantly changed from 2.9±0.54g (cowpeas) to 22.58±0.72 (chickpeas). Research on improving seed system of the pulses should be done and district nutrition officers should put more emphasis on nutrition education in processing and utilization for farmers of the pulses.

[1] boiled and add oil, tomato and onion

[2] Just boiled pulse and eat as snack or roasted

[3] decorticated nuts that are boiled and mashed

Paper Number: 1253 (Poster Number: 197)

Probiotic Tolerance to Simulated Gastric and Bile and Shelf Life Characteristics of Bambara Groundnut (*Vigna subteranea* (L.) Verdc) Probiotic Beverage.

*Yvonne Yeukai Murevanhema** and *Victoria Adaora Jideani*, Cape Peninsula University of Technology

Gastric juice, and bile tolerance and shelf life of Bambara-groundnut probiotic beverages (BGNPB) are not documented to the best of our knowledge. BGNPB, fermented with (1) *L. bulgaricus* and (2) *L. bulgaricus* and *L. plantarum* were assessed for probiotic tolerance to simulated gastric juices and bile in vitro and a 28-day shelf life study at (5, 15 and 25°C). Concentrations of the gastric juice, bile and time of incubation of the BGNPB had significant ($p < 0.05$) effect on the percent survival of the probiotics. Probiotic survival was 32.9%, after 180 min at pH 3.0 in the gastric juice and 32% survived after 180 min in 0.3% bile. Survival at pH 3 is significant as ingestion of food raises the stomach pH to 3 or above. Microbial load after the 28 days was 7.05 Log cfu/mL for *L. bulgaricus* and 7.11 Log cfu/mL for *L. bulgaricus* and *L. plantarum*; BGNPB at 5°C. However no probiotic was detected at 15 and 25°C for the two BGNPB. Shelf life was 28 days (right censored) for both BGNPB stored at 5°C, 18 days and 10 days, respectively for (1) *L. bulgaricus* and (2) *L. bulgaricus* and *L. plantarum* at 15°C, 2 days for both at 25°C. The probiotics in BGNPB can survive the gastric juice and bile, and transit through the gastric intestinal tract to the colon in numbers large enough to confer its benefits to the host. Furthermore the probiotic beverage can keep for long on the shelf before it loses effectiveness.

Paper Number: 1254 (Poster Number: 198)

Evaluation of Cooking Time, Crude Fiber and Crude Protein Contents in Newly Introduced Dry Bean Varieties.

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Marketability, cooking period and taste are important traits influencing adoption of the new varieties. However, breeders have concentrated on producing high yielding bean varieties that withstand diverse stress environments during production process. A study was carried out to determine cooking time and level of protein and fiber of newly introduced dry bean varieties. Four varieties were evaluated namely GLP92, ECAB 702, ECAB 703, K131 and control variety GLP2. All the varieties were significantly different at $p < 0.001$ in cooking time. All the bean varieties cooked in less than 2 hrs therefore were classified as Easy-to-cook varieties. Overall the improved varieties took the shortest period compared to old variety GLP2. The study also showed that soaking reduced the cooking time of all the varieties. GLP2 had the highest level of crude protein (20.10%) while GLP92 had the lowest (17.89%). There was no significant difference at $P < 0.0001$ of K131 (17.57%), ECAB 702 (17.35%), ECAB 703 and GLP 2 on the level of crude protein. The level of crude protein in dry beans ranges from 16%-33% therefore all the varieties were within.

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There was no significant difference on the level of crude fiber among all the varieties. The level of dry bean fiber content was below the range of 14-19%. The results indicated the introduced varieties are commercially viable compared to the old variety GLP2.

Key words: Dry bean, cooking time, protein, crude fiber

Paper Number: 1255 (Poster Number: 199)

Evaluation of Cooking Characteristics of Six Different Pigeon Pea Varieties.

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Prolonged cooking time is one of reasons that affect utilisation of pigeon peas due cost of fuel. The study was done to examine if seedcoat thickness affect cooking characteristics of six varieties of whole and dehulled pigeon pea varieties. Five kilograms of each of the following different pigeon pea (*Cajanus cajan* L.) varieties: Sauma, Mwaiwathualimi, Kachangu, ICEAP1514/15, Nthawajuni and ICEAP 93026 were obtained from ICRISAT in Lilongwe. Determination of the following was done: seed coat thickness, water absorption during soaking and cooking, splitting during cooking and cooking time. The data was analysed using SPSS version 20. ICEAP 93026 had thinner seedcoat (0.16 ± 0.04 mm) while Kachangu had relatively thicker seedcoat (0.21 ± 0.04 mm). Nthawajuni (whole and dehulled) had high water absorption during soaking (1000g/Kg). Whole seeded ICEAP 93026 had low water absorption during soaking (750g/Kg). Kachangu had lowest cooking time (97minutes). Nthawajuni had longest cooking time (193 minutes). Dehulled Kachangu cooked faster (28 minutes). Dehulled ICEAP01514/15 cooked at 54 minutes. Kachangu and Mwaiwathualimi had 60% of splits after 90minutes of cooking while Sauma had 10% of splits. Mwaiwathualimi had high water absorption during cooking (1414.37 ± 72.4). Sauma had low water absorption during cooking (1168.37 ± 20.5). Varieties which had high water absorption cooked faster and had high incidences of splitting during cooking. Seedcoat thickness did not influence cooking characteristics but dehulling reduced cooking time. Dehulling should be promoted as it reduce cooking time. Research on new products/ recipes form pigeon pea to be done.

Paper Number: 1256

Innovations in Grain Legume Seed Systems.

Louise Sperling, Catholic Relief Services*

This presentation reviews the seed systems smallholder currently use to source their range of legume crops (groundnut, common bean, cowpea, pigeon pea, greengram). Drawing from the largest known seed transaction data set available, data show that the lion's share of legume seed, <93% comes from the informal sector, including 65% from local markets. This contrasts with the key formal sector source, agro-dealers, which provide >1% of the total legume seed sown. New strategies are needed to make both the formal and the informal seed sector more smallholder client-responsive; that is, able to provide the new varieties and higher quality seed farmers want and need. Innovations and advances of the last five years are reviewed in reference to : product design, delivery, seed production and seed/crop policy. reform Bottlenecks remain and these are prioritized.

Paper Number: 1257

Panel Discussion on Seed Systems.

Jean Claude Rubyogo, International Centre for Tropical Agriculture (CIAT), Asnake Fikre, Ethiopian Institute of Agricultural Research, Charles Katabalwa, CEDO SEEDS, Issa Drabo, Institut de l'Environnement et de Recherches Agricoles and Cynthia Donovan, Michigan State University*

After each panelist gives a very brief introduction to his/her work, the moderator will use a set of directed questions for the panelists concerning the constraints and opportunities in grain legume seed systems. The panelists will respond with examples of how seed systems development can be achieved and continued challenges.

Paper Number: 1258

High Throughput Plant Phenotyping for Adaptation to Drought-Prone and Low Phosphorus Environments in Cowpea: Recent Progress and Future Prospects.

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Water deficit and poor soil fertility are the major environmental factors limiting crops yield and productivity in the semi-arid tropical regions of Sub-Saharan Africa where cowpea, an important food and cash legume crop is widely cultivated under rain-fed conditions by resource-limited farmers. Plant shoot and root phenes that confer the ability to (i) maximize subsoil foraging, (ii) enhance available water and nutrient capture, and (iii) optimize these resources use efficiency, are crucial for the crop adaptation and sustainable production in marginal environments. Here we describe innovative and precise plant phenotyping techniques including field and lab (shovelomics, image analysis), lysimetric platform and controlled gravimetric pot experimental protocols. We also present and discuss findings of substantial phenotypic variations in root system architecture (root growth angle, number, density, and diameter), shoot water saving related traits (canopy area development, leaf conductance), and other relevant agronomic and physiological parameters (pod harvest index, leaf temperature depression, leaf relative chlorophyll content) among diverse sets of cowpea germplasm. However, the traits themselves are dynamics and interact with one another and with the environment, and agronomic management eventually influences their response, synergism or trade-off. Therefore, for effective breeding of more drought and low fertility resilient cultivars, crop-climate simulation modeling becomes an essential tool for navigating the biological complexity, testing and predicting the effects and probability of success of specific traits or trait combination, and combining both genetic and agronomic options to maximize crop productivity in a given environment or stress scenario.

Key-words: agriculture, climate change, food security, root system, simulation modeling, *Vigna unguiculata*, water conservation.

Paper Number: 1259

Morpho-Physiological Traits Linked to Drought Tolerance in Chickpea (*Cicer arietinum* L.).

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*MORPHO-PHYSIOLOGICAL TRAITS LINKED TO DROUGHT TOLERANCE IN CHICKPEA (*Cicer arietinum* L.)*

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Abstract

Roots are among the first defence towards drought with other morpho-physiological and biochemical mechanisms employed by plants. This study determined the root characteristics associated with water stress tolerance in selected chickpea lines and grain yield performance under water stress field conditions in ASALs of Kenya. The genotypes were evaluated under rain shelter in Polyvinyl chloride (PVC) cylinders (120 cm long x 20 cm diameter) in a completely randomized block design. The field experiment was conducted at two site under rainfed for two seasons (2013/2014), in 3 replicates. Results showed a large variation in root biomass (0.16 -077gms/plant) was observed. Genotype ICCV 92944 had the greatest root biomass followed by ICC 283 and ICCV 97306 while genotype ICC 4958 had the highest root length density (RLD) and longest roots, followed by ICC 283 and ICC 3325. Genotypes ICCV 92944, ICCV 00108 and ICC 4958 had highest shoot biomass. These traits were correlated with drought. Field results showed that genotypes ICCV 92318 and ICC 1882 had the largest seeds in Marigat (irrigated) and Chemeron (rainfed) sites respectively. Grain yield ranged from 112-867 kg ha⁻¹ in both conditions. Genotype Cavir was the largest genotype. The findings of this study showed that drought tolerance traits such as root biomass, RLD, shoot biomass and root length of genotypes could be used for indirect selection for drought tolerance. Genotypes ICCV 92944 and ICC 4958 are good sources of root traits for improving susceptible genotypes to enhance water uptake and improve drought tolerance in chickpea.

Key words: Genotypes, drought stress, Root length density (RLD) and root biomass

Paper Number: 1260

Physiological Characteristics Leading to Differences in Drought Tolerance in *Phaseolus vulgaris* and *P. acutifolius*.

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Drought represents a major limit to bean production: production areas frequently experience suboptimum precipitation, and many cultivars are drought sensitive. Further, heat often exacerbates drought effects. Consequently, breeders seek to improve drought and heat tolerance. Using gas exchange, new fluorescence parameters, metabolomics, and biochemical assays, we assessed numerous genotypes with varying degrees of stress tolerance, including tepary (*P. acutifolius*), to find traits correlated with drought tolerance. Metabolomic studies showed most components little changed 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. Slowly increasing temperatures showed no effects until 45°C when gas exchange, fluorescence, oxidative stress, and visual assessments indicated distinct genotypic differences. New fluorescence methods were useful for heat tolerance screening, but only partially related to field observations of drought tolerance. Plant breeders can easily use several of these methods to supplement field data and characterize stress tolerance of bean lines. Most importantly, breeders should emphasize selection for lower stomatal conductances to improve drought tolerance in bean germplasm.

Paper Number: 1261

Molecular Mapping of Heat Tolerance in Cowpea.

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Cowpea is an important legume food crop in many parts of the world, including Texas and other U.S. Southern States. However, the yield of cowpea is low due to numerous biotic and abiotic factors. Therefore, a breeding program has been initiated to develop cowpea varieties with tolerance to the stresses, including heat, drought and major pests. The materials for this study were selected from 41 cowpea varieties, which showed major variation in heat tolerance in the 2011 field near College Station, Texas. Two genotypes distinguishing in heat tolerance, IT98K-476-8 (susceptible) and Golden Eye California (tolerant) were selected and used to develop a population of RILs (F₂:8) in order to map the QTLs controlling heat tolerance. These RILs along with the parents were evaluated in heat tolerance in both greenhouse and in the fields near Corpus Christi and Weslaco, Texas in 2015. The high temperature for plant heat stress ranged from 38 to 41°C and the low temperature was 25 to 28°C at all the locations during flowering time. The result showed that the number of heat tolerant RILs was close to that of heat susceptible RILs, indicating a major gene responsible for the heat tolerance. To map the gene(s), we sequenced the population using the RAD-seq technology, from which we identified 6,001 SNPs distributing in 3,256 haplotypes. Of the 3,256 haplotypes, 2,378 were selected to construct a linkage map of the cowpea genome. The map currently consists of 11 densely covered linkage groups. The phenotypic data in heat tolerance from both greenhouse and field and the genetic map are being used to map the gene(s) or QTLs responsible for heat tolerance.

Paper Number: 1262

Genetic Analysis of Common Bean (*Phaseolus vulgaris* L.) for Yield and Yield Components Under Managed Drought Stress Conditions.

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Many of the world's common bean (*Phaseolus vulgaris* L.) growing regions are prone to either intermittent or terminal drought stress, making drought the primary cause of yield loss under farmers' field conditions. The aim of the study was to assess the inheritance of yield and yield related traits under moisture stress conditions among Zambian genotypes. Sixty four (64) genotypes comprising of 14 parental lines, two checks and 48 F₂ populations were grown in an 8 x 8 alpha-lattice design with two replications at two sites, Nanga and Mount Makulu under managed drought conditions during the year, 2013 in Zambia. Significant differences were recorded among the genotypes for yield and number of seeds per pod. General combining ability effects and specific combining ability effects were significant for the two traits under managed drought stress conditions implying that both additive and non-additive gene effects were important in their inheritance. ZM 4497 and Ly4-4-4-B were found to be the most drought tolerant male parents with positive GCA effects and their F₂ combinations were in the top 10 highest yielding F₂ populations for SCA effects for yield.

The heritability estimate for yield was 60% which implied that progress can be made during selection for yield.

Paper Number: 1263

Identification of Drought Resistant Germplasm for Uganda and Zambia.

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Drought is the most limiting worldwide abiotic factor affecting dry bean production not only reducing yield but also reducing quality. The severity of yield reduction depends on the timing and duration of drought stress. Cooking time is a major concern in Africa because longer cooking time requires use of more energy resources. Cooking time may also be affected by drought. This work is being conducted in Uganda, the U.S., and Zambia and focuses on identifying sources of drought resistance. Cooking time of the drought resistant lines was also measured. During 2013 and 2014 drought resistant lines derived from a Puerto Rico-Nebraska shuttle breeding nursery and the Andean Diversity Panel (ADP) were evaluated under both irrigated and drought conditions (no irrigation after flowering) in western Nebraska. Seed yield and 100-seed weight were reduced 41.2 and 9.6%, respectively, when beans were grown under drought stress. Geometric mean yield (irrigated and drought stressed combined) was greatest for VA-19 followed by Bilfa 4, Bukoba, A 800, and Krimson (3035, 2418, 2349, 2100, and 1973 kg ha⁻¹, respectively). On average, beans grown under irrigated conditions cooked in 59 minutes whereas those grown under drought stress cooked in 68 minutes. Based on results from the Nebraska experiments, a drought trial of 60 entries was established in Uganda and Zambia during 2015. In both locations beans were evaluated for drought resistance. Also in 2015, F1 hybrids were initiated to improve African cultivars/landraces for drought and multiple disease resistance. Faster cooking time was also taken in consideration.

Paper Number: 1264

Adaptability of Cowpea Genotypes in Different Agroecologies of Mozambique.

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Cowpea (*Vigna unguiculata*) is an important household food security crop in northern part of Mozambique that is vulnerable to frequent drought and floods due to climate change resulting in low yields. This study evaluated adaptability of 20 cowpea genotypes to drought and excess rainfall tolerance in three agroecologies of Mozambique; Nampula (Muriaze and Namialo), Sussundenga and Ruace with varied rainfall regimes and intensity using a completely randomized design. Another trial was established to determine the best planting date by assessing the growth, yield and yield components using a sub-set of six genotypes grown across four dates during the 2013/2014 and 2014/2015 seasons. A split-plot with planting date as main plots and varieties as sub-plots was used for this study. Data collected on crop development and growth, nitrogen fixation (nodule population and dry weight), yield and yield components (biomass, seed weight, number of pods) and days to reach specific growth stages were analyzed in PROC GLM (SAS 9.4). Cowpea genotypes yields varied with agro-ecologies. For instance, the highest yield at Muriaze was 1542 kg ha⁻¹ (IT04K-227-4), Namialo 2517 kg ha⁻¹ (IT04K-321-3) and Sussundenga 2482 kg ha⁻¹ (IT99K-573-1-1). Other parameters measured also differed among genotypes and locations. Early planting (second week January), resulted in higher yields (1015 - 1574 kg ha⁻¹) for 2013/2014 and (1190-1660 kg ha⁻¹) for 2014/2015 season which declined with delayed planting and varied with agroecologies. Information on genotypes adaptation and planting will enable target variety recommendation to farmers in the different localities of Mozambique.

Paper Number: 1265

Use of Root Traits in Screening Common Bean (*Phaseolus vulgaris* L.) Genotypes Tolerant to Drought in Mozambique, Malawi and Zambia.

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Use of root traits in screening common bean (*Phaseolus vulgaris* L.) genotypes tolerant to drought in Mozambique, Malawi and Zambia M.I.V. AMANE¹, V. CHISALE², K. MUIMUI³, R. CHIRWA⁴, S. CAMILO¹, C. JOCHUA¹, M. MIGUEL¹ IIAM, Av. FPLM 2698, Maputo, Mozambique 2DARS, Chitedze Research Station, P.O. Box 158, Lilongwe, Malawi 3ZARI, House no.2, Misamfu Regional Research Station, Box 410055, Kasama, Zambia 4CIAT, Chitedze Research Station, P.O. Box 158, Lilongwe, Malawi Corresponding author: mivamane@gmail.com Abstract Experiments were conducted in 2014, simultaneously in Mozambique and Malawi to understand the effect of root architecture in common bean genotypes on resistance to terminal drought. One set of the experiment was grown under terminal drought, where irrigation was cut off at flowering stage and under full time irrigated conditions (no moisture stress).

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At 45 days from planting 3 representative plants per plot in each replication were randomly excavated and gently washed with water. The roots were preserved in the zip-lock bags filled with 50% of ethanol solution, while hoots were placed in the paper bags. A total of 225 samples were collected from the field, where 10 root traits were assessed Adventitious root number (ARN); Basal root whorl number (BRWN); Basal root number (BRN); Tap root lateral number (TRLN); Basal root growth angle (BRGA); Stem diameter (SD); Taproot diameter (TD); Taproot branching density (TBD); 2nd order basal density (2BD); Nodulation score (NS); The shoot samples were dried and weighed. Genotypes with deeper angles or BRGA and small TD showed high shoot growth weight and better yield under drought conditions, and based these criteria 25 genotypes were selected for further studies. Keywords: Bean genotypes, root traits, terminal drought.

Paper Number: 1266

The Incidence and Severity of Common Bean (*Phaseolus vulgaris* L.) Pests in Different Agro Ecological Zones and Smallholder Farms in Western Kenya.

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The infestation of insect pests is a serious problem in legume upscaling activities and a threat to future production in Kenya. A survey was conducted for two seasons in 2013 to determine incidence and severity of insect pests of common beans in six indifferent agro ecological zones of western Kenya. Foliage beetle occurred in 83.9% and 91.5% of the farms visited. The hot and drier LM3 (72.6%) and LM4 (92.1%) zones recorded the highest incidence of foliage beetle during the two seasons. Leaf hopper incidence was highest in LM4 (26.8%) and (59.3%) whereas bean fly incidence was highest in UM3 (12.4%) and LH1 (2.9%) . Whitefly incidence was highest in LM3 (13.0%) and LM2 (17.9%) and aphid incidence was highest in LM1 (16.5%) and UM1 (40.8%). Plant bug incidence was highest in LM1 (16.5%) and LM2 (5.8%). Flower thrips incidence was highest in LM2 (20.7%) and (34.2%) in both seasons. Bean flies, web worm, pod borers, plant bugs and semi looper incidences were higher during long rains. Foliage beetle, whiteflies, aphids, leaf hopper, flower thrips and grasshoppers were higher during the short rains. Flower thrips, bean fly and pod borer incidences and severity was lower on improved cultivars. Intercropping reduced the incidence of aphids. Inorganic and organic fertilizers reduced the incidences of foliage beetle, flower thrips, pod borer and leaf hoppers but increased the incidence of aphids. Bean fly incidence was lower in farms using organic fertilizer. The result is important in the management of bean insect pests. Key words: Insect pest incidence, *Phaseolus vulgaris*, agro-ecological zones, Kenya

Paper Number: 1267

Progress in Sustainable Management of Cowpea Pests in West Africa.

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ABSTRACT

Cowpea is a nutritious leguminous crop of the West African sub region where it serves both as a subsistence and commercial crop. The dry seeds are eaten in various preparations while the green pods and leaves are eaten as vegetables. The haulms of cowpeas are important fodder materials in livestock-crop mixed farming systems. However, cowpea production is hampered by several factors key among which is pestilence by a myriad of pests and diseases. Much research effort had been devoted to sustainable approaches to suppressing pests and diseases. From selecting for tolerance among landraces at the level of the indigenous farmers, progress had been made through use of synthetic pesticides in calendar applications, to other formats for reducing the amount of toxic pesticides sprayed including the use of plant extracts. Recently the underlying principle has been sustainable IPM incorporating the use of all compatible approaches. This has been pursued through the adoption of biological based pest management approaches. Semio-chemicals have been introduced for monitoring pest populations and in early warning systems thus making it easier to use others such as biopesticides timeously and efficiently. Natural enemies have also been imported, released and supported with establishment of alternative host plants to serve as refuges in the off season. While some of these have been done on the blind side of the farmer, others such as use of environmentally friendly pesticides as neem and other plant extracts and more judicious use of pesticides to facilitate the establishment of natural enemies requires farmers' active involvement. The dissemination of these technologies had hitherto been carried out by extension personnel but their work is usually hampered by lack of information and inability to access the farmers. The introduction of short animations downloaded onto cell phones in the new IPM-OMICS project will both expedite the information flow for extension staff and farmers.

Paper Number: 1268

De Nouvelles Variétés De Niébé Résistantes Aux Striga Avec La Participation Des Producteurs Au Togo. Tchabana B1.; Assignon K1. ; Banla E1.; Kpémoua K1. ; Tignegré J-B2 ; Et Timko P.M3. 1 : Institut Togolais De Recherche Agronomique/Crass/Itra 2 : Insti.

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De nouvelles variétés de niébé résistantes aux Striga avec la participation des producteurs au Togo. Tchabana B1.; Assignon K1. ; Banla E1.; Kpémoua K1. ; Tignegré J-B2 ; et Timko P.M3. 1 : Institut Togolais de Recherche Agronomique/CRASS/ITRA 2 : Institut National de recherche Agricole/INERA/CREAF 3 : Université de Virginia/USA Résumé Le niébé, importante légumineuse vivrière à graines, est menacé par le Striga gesnerioides dans les zones à forte production. Après des travaux de recherche sur la mise en place des variétés résistantes au Striga, six variétés ont été évaluées en milieu réel avec la participation des paysans en vue d'identifier celles qui résistent et produisent plus par rapport à la locale. Trois zones à forte pression parasitaire dont Dapaong dans les Savanes, Sirka dans la Kara et Wogba dans la maritime ont servi les zones d'essai où le Striga constitue un foyer privilégié. Après deux années de recherche, deux variétés à savoir IT97K-499-35 et K VX771-10G ont présenté moins de plants de Striga germé ou émergé par rapport aux autres variétés qui sont équivalentes. Le rendement moyen de ces variétés a été plus important par rapport aux autres variétés. Les producteurs en particulier les femmes ont également apprécié ces deux variétés sur la base de la couleur et grosseur des graines qui ont été des critères pour la vente au marché lors des journées croisées. Il est évident de produire des semences de ces deux variétés pour les mettre à la disposition des producteurs de ces zones. Mots clés : Variétés résistantes ; participation ; Striga gesnerioides ; zones à forte pression parasitaire ; Togo.

Paper Number: 1269

Improving the Field Resistance of Cowpea Genotypes to Cowpea Aphid.

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One major setback of the agricultural sector is the prevalence of diverse insect pests mitigating crop growth and development. Cowpea is considered the second most important grain legume grown in Northern Ghana. Despite its adaptation to poor soils and drought, the crop fails to attain its stipulated yields due to the vast array of biotic stress of which the cowpea aphid plays key damaging roles. Farmers thus resort to the use of chemicals in an attempt to rescue their crops. Chemicals are not only expensive for the peasant farmer but also harmful to humans and other biological lives. The use of resistant crop varieties therefore presents an environmentally friendly and economically sound approach. On-going research between UCC and SARI in Ghana under the Legume innovation Lab project has screened seven newly improved Striga gesnerioides resistant and high yielding cowpea lines for aphid resistance. Results obtained from seedling stage screening found three of the lines showing resistance whereas four were susceptible. Both resistant and susceptible lines were subsequently crossed to SARC-1-57-2, a known aphid resistant cowpea genotype with the objective of improving the field resistance of the susceptible lines to aphid and to assess whether the resistance gene in the resistant lines are the same as that in SARC1-57-2. Pyramiding of aphid resistance genes will then be our ultimate goal if different genes are found controlling resistance in these lines. We anticipate our results will provide cowpea farmers better alternatives to maximize on-farm yields as well as ensuring food security.

Paper Number: 1270

Pea Weevil (*Bruchus pisorum* L.) Is Threatening Field Pea Production in Ethiopia: Prospects of Integrated Pest Management (IPM).

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Field pea is the second most important grain legume crop in Ethiopia. Pea weevil (PW) is a major pest of field pea in Ethiopia and worldwide. Current control practices of PW rely on chemical insecticides, which are unaffordable for most small-scale farmers in developing countries. Development of IPM strategies for PW is vital for sustainable production of field pea. This study mapped Ethiopian farmers' knowledge and practices to control PW and investigated host plant resistance in field pea. A survey conducted in four field pea-growing districts in Ethiopia showed that PW is established in the major field pea-growing areas, causing severe crop losses. The logit model showed that farmers' knowledge of PW was positively and significantly predicted by gender, farming experience and membership of cooperatives. Furthermore, some farmers' cultivation practices inadvertently enhance infestation of the weevils. To resolve this knowledge gap, it is important to provide training for these farmers. Among 602 field pea accessions evaluated for their resistance to PW, only a few accessions showed moderate levels of resistance. Some accessions possessed the Np gene, which is responsible for formation of neoplasm on the pod surface of peas and these accessions had received lower number of eggs.

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Furthermore, Adet was an attractive genotype for oviposition, while non-host plants (*Pisum fulvum* Sibth. et Sm. and *Lathyrus sativus* L.) were less preferred by females. Results obtained from this study can be used in developing alternative pest management strategies such as trap cropping using highly attractive genotype and intercropping with the non-host plants.

Paper Number: 1271

Evaluation and Validation of Innovative and Environmentally Friendly Integrated Disease Management (IDM) Strategies through Participatory Research on Beans in Zimbabwe.

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Abstract

Diseases are a major constraint to common bean production in Zimbabwe. Level of infection may vary depending on the season and management practices used. Integrated disease management (IDM) is needed to address the challenge. This study sort to identify the best practical IDM options which reduce the occurrence and severity of Angular Leaf Spot (ALS) for smallholder farmers. The research was conducted for two seasons (2013 and 2014) on a total of eight on-farm and one on-station trials, which consisted of five treatments planted in a complete randomized block design (CRBD): (1) Planting on Raised Beds+ Foliar Spray with Dithane M45 (PRBFD), (2) Disinfecting the seed with Sodium Hypochloride + Foliar Spray with Dithane M45 (DSHFD), (3) Seed Dressing with Thiram + Foliar Spaying with Dithane M45 (SDTFD), (4) Planting on Raised Beds + Seed Dressing with Thiram+ Foliar Spray with Dithane M45 (PRBSDTFD), and (5) control. Disease spots on leaves were recorded at 2nd and 4th week after germination, at flowering, pod formation and harvesting. ALS disease severity for treatment PRBSDTFD was significantly different ($p < 0.05$) from the other treatments. ALS severity was most severe on untreated plants. The next set of treatments which had low disease severity were PRBFD and SDTFD. It was observed that there was no significant difference in disease incidence of the two varieties used. The study recommends planting beans on Raised Beds and Seed Dressing combined with foliar spray for ALS management by small holder farmers.

Key words: Evaluation, validation, innovative

Paper Number: 1272

Participatory Integrated Pest Management for Increased Cowpea Production in Northern Ghana.

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Abstract

Cowpea is an important source of protein for human and animal nutrition in many parts of the semi-arid tropics. Cowpea yields at farmers' levels in Northern Ghana are low and the yield reducing factors include insect pests, *Striga* infestations and low adoption of recommended or improved production methods. Under the auspices of the International Institute for Tropical Agriculture, the CSIR-Savanna Agricultural Research Institute and its partners are promoting technologies to increase cowpea productivity through the USAID Cowpea Out-scaling project for increased food security. The participatory Integrated Pests Management technologies include host plant resistance in controlling *Striga gesnerioides*, good agricultural practices in combination with minimum insecticide application and planting. The first year results from the participatory field demonstrations and training led to the following achievements. The *Striga*-resistant cowpea variety, Songotra, introduced to the farmers had helped increase cowpea yields with few or no *Striga* infestations across the three regions. Secondary, it was also demonstrated to the farmers that a combination of good agricultural practices such as good soil tilth, planting in line, timeous weeding ensured optimal plant density and higher yields compared to framers' practices. Additional, two insecticide sprays at the early stages of flowering and full podding could produce yields comparable to three or more sprays. It was also demonstrated to the farmers that planting at the recommended time reduced the incidence of pests and increased yields. These achievements will be out scaled out to many more cowpea growing communities over the project's period to increase cowpea production in Northern Ghana.

Paper Number: 1273

Preliminary Study of the Presence, Damage LEVEL and Population Dynamics of Mexican POD Weevil (*Apion godmani*) in Bean Genotypes (*Phaseolus vulgaris* L.), in the Highlands of Guatemala.

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The Mexican pod weevil *Apion* sp., is considered one of the main pests of common bean (*Phaseolus vulgaris* L.). In the highlands of Guatemala, it is one of the most limiting factors for production because of direct damage to the seed during its formation. The damage caused by the weevil goes unnoticed by most bean producers because it's a very small insect and the damage is caused to the growing seed inside the pod. Insect damage can be up to 100% in some severe cases. We have identified two species *A. godmani* and *A. aurichalceum*. *A. godmani* attacks both climbing beans and bush beans, while *A. aurichalceum* only attacks climbing bean varieties. We did a preliminary study to determinate the presence of the pod weevil in bean, the level of damage and population dynamics, in both bush and climbing types, on-farm and at the experimental station of Labor Ovalle, Quetzaltenango. We found the presence of the insect in all the samples taken. In farmers' fields where bean genotypes were evaluated, ICTA Texel, Criollo and ICTA Labor Ovalle showed damage in seeds in a range from 14% to 99%, with an average of 45%. At the experimental station, seven samples were taken, in four genotypes; two bush and two climbing types. Among the bush genotypes, ICTA Hunapú and Bayo Azteca, the average seed damage is 35% and 38%, respectively. In the climbing types, average seed damage were 83% for ICTA Texel and 67% for ICTA Uatatlán. In the climbing types the damage was higher, possibly because of its cycle being longer than the bush types. As for the evaluation of the population dynamics, weekly samplings were made from 75 days after sowing, finding that the presence of adult pod weevil was higher between the sixth and ninth week of evaluation. Finding a total of 112 adults in that period in ICTA Uatatlán and 86 adults for ICTA Texel genotype.

Paper Number: 1274

Assessing Effectiveness and Sustainability of Small Seed Packs Approach in Disseminating New Bean Varieties in Kenya.

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This study aimed to increase farmers' access to improved bean seed in marginal/drought prone areas of Kenya. In Kenya, only a few companies/organizations market certified bean seed to government and humanitarian organizations rather than creating a sustainable seed market. The main reason is attributed to inadequate marketing targeting small holder farmers. The demand side for bean seed has also faced a number of challenges. Many farmers do not know about new varieties while conventional models of bean seed delivery in Africa, centralized with National Agricultural Research Systems (NARS), are slow, subsidized and of limited reach. The small packs marketing approach is based on field insights that farmers want access to new varieties, and some also are willing to pay for certified seed in affordable packs. Between 2012 and 2014, the number of stockists selling new drought tolerant seed increased from zero to 4, 1 and 3 in Narok, Homabay Kisumu counties respectively. During that period, the amount sold by Dryland seed company were 5,000kg, 875kg, 8,028kg, 4,712 and 4,033 for seed sizes 100g, 250g, 0.5kg, 1kg and 2kg respectively. The small seed packs technology is opening up novel and sustainable business opportunities for the private sector and thousands of farmers are actually buying certified seed. This approach has created opportunities to reach the vulnerable but viable small holders, 67.2% of farmers surveyed were >40 years; stimulated private sector interest in bean seed marketing, broadening client base; increased access to new technology; financial viability for both farmers and private sector. Key words: Beans, seed small pack, access to new varieties, innovative approach, willing to pay and business opportunity 1

Paper Number: 1275

Public-Private Partnership Enhances Seed Production and Utilization By Bean Farmers in Rwanda.

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Seed security is a major pre-condition to increased productivity and food security for the smallholders. This is particularly true for Rwanda where land pressure is acute. Use of quality seed of bush and climbing beans increases yields by three and six-folds respectively. While Rwanda released over 50 high yielding and farmer-acceptable bean varieties with relatively high adoption rate (>60%), on-farm productivity remained dismal (>5 times less) compared to potential. This was partly attributed to low use of improved seeds (<3%). The seed value chain is largely public dominated and centralized with negligible participation by the private. About 95% of the seed supply comes from informal sources: farmer-saved or markets. The seed operation plan envisages to achieve 25% of bean seed needs in Rwanda by 2017 through sustainable seed production and marketing systems. We created platforms of researchers, seed companies, contract producers, agro-dealers, NGOs, extension services community-based organizations, media and financial institutions with well-defined, interactive and complementary roles along the production to marketing seed value chain. We did regular sensitization and promotion by media, farmer trainings, demonstrations and field days. Seed distribution system was through multi-channels particularly by open-market, pay-back, agro-dealer networking in bulk and small-packets purchase schemes. After two years after the public-private partnership initiative, commercial seed production accelerated ten times and reached 85.3% of the target or jumped from 1.6% to 13.6 % of the projected national bean seed demand as per the current seed operation plan. This means the 25% target of the demand for 2017 is tenable under the initiative.

Paper Number: 1276

Farmer Willingness to Pay for Quality Bean Seed: Experimental Evidence from Tanzania.

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An important factor determining the sustainability of a seed system is the 'effective demand' for seed by farmers. Low seed demand is often cited as a major reason for the lack of private-sector involvement in the seed system for self-pollinated crops such as beans for which 'seed' often competes with 'grain' as planting material. On the demand side, the viability of a seed system depends on whether farmers can perceive the 'seed' product as a quality planting material, and whether they are willing to pay a premium price for seed compared to grain price. This study uses data from field experiments (FE) and bidding experimental auctions (BEA) conducted with 113 bean farmers from 6 villages in northern Tanzania to gauge the demand for four types of seed products: certified 1 seeds, certified 2 seeds, quality declared seeds, and recycled seeds from previous harvest. Results indicate that farmers are willing-to-pay higher price for higher perceived seed quality. On average the relative price differential between recycled seed (which had the lowest average bidding price) and certified 1 seed (which had the highest average bidding price) was 28%. QDS received an average bidding price similar to the bidding price for recycled seed. More research is needed to investigate: 1) whether the seed system can supply seed of 'certified 1' quality at a price most farmers are willing-to-pay, and 2) whether the quantity and frequency of seed demanded at that price is large enough to attract suppliers to produce and sell quality seed.

Paper Number: 1277

Innovative Partnership Approach to Chickpea Seed Production and Technology Dissemination: Lessons from Ethiopia.

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In spite of the availability of several improved chickpea technologies generated by the research system in Ethiopia over the last four decades, large scale adoption of these technologies by smallholder farmers has not been achieved. This has led to the stagnation of agricultural productivity and low crop yields, exposing the country to recurrent food shortfalls and national food insecurity. The average national use of improved seeds is as low as 5% of the cultivated area. A seed marketing study of November 2000 commissioned by the Ethiopian Seed Enterprise (ESE) indicated that the potential size of the certified seed market in the country ranges from 75,000-100,000 tons/year. On the other hand, the supply is about 20,000 tons/year.

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This difference between demand and supply means that the formal seed sector cannot ensure farmers' easy access to seeds of improved varieties. About 60-70% of the seed used by the Ethiopian smallholder farmers is saved on-farm, while remaining 20-30% is borrowed or purchased locally. Legume seeds are less profitable to seed companies for several reasons: uncertain and fluctuating demand caused by competition from farm-saved seed (grain legumes), low multiplication rates (grain legumes) and strong regional or local preferences. Through the support of TLII project, EIAR introduced a successful paradigm shift to filling in the seed demand gap, based on the innovative approach involving partnerships with several actors along the chickpea seed value chain, especially farmers, farmers' cooperatives, input dealers and other stakeholders involved in agricultural development.

Paper Number: 1278

Scaling out Cowpea Production in Northern Ghana the Community Seed Scheme.

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Abstract

The importance of cowpea in food and soil fertility enhancement cannot be over-emphasized. Over the years, CSIR-SARI in collaboration with IITA has released several improved cowpea varieties with the aim of reducing poverty and malnutrition in Northern Ghana. However, these seeds have not come within the reach of the resource-poor farmers due to their lack of knowledge and limited availability of the improved seeds. The quest to enhance the accessibility of improved cowpea seeds culminated into the USAID Cowpea Project under the auspices of the International Institute of Tropical Agriculture in collaboration with CSIR-SARI and her development partners. Community seed production which is one of the major strategies of the project were established in 152 communities across the three regions which served as training grounds for the farmers. Protocols for good agronomic practices were developed to guide Agricultural Extension Agents in training the farmers towards the execution of the scheme. In all about 26 hectares were planted foundations seeds with an expected output of 22-26tons of certified seeds. A revolving system has been set up in which each farmer group after harvesting, returns 1.5 times the equivalent of seeds received from the project. The seeds recovered in the 2015 will be supplied to farmers from other communities during the 2016 cropping season. The participating farmers are encouraged to sell the rest of the seeds to members of their communities. These structures are to enhance farmers' access to improved cowpea seeds and therefore increase cowpea production and productivity.

Paper Number: 1279

Quality Declared Seed - Filling the Gap Between Formal and Informal Seed Systems: A Case of Common Bean and Groundnut in Uganda.

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Numerous constraints limit the performance of seed systems in Uganda. The most important being limited access to seed of newly bred varieties; and limited supply farmer and market preferred varieties of certified seed. To enhance agricultural productivity, seed systems need to deliver high-quality seed of a range of crops and varieties. The three agro-ecological zones where Integrated Seed Sector Development (ISSD) programme is working in Uganda are West Nile, Northern and South Western Uganda. In 2013, 60% of the farmers grew common beans on slightly less than one acre, using 23 kg of seed. For groundnut, this is 38%, on 0.87 acre using 18 kg of seed. The main seed sources for bean and groundnuts are farm-saved (46%), Neighbours (2%), local market (42%), Local Seed Businesses (2%), agro-inputs dealers (4%), government (3%) and NGOs (1%) (ISSD Uganda, 2014). This shows that 90% of seed comes from the informal seed system, which represents in many cases grain being used as seed. The Local Seed Businesses, which were just starting in 2013, can play a crucial role in providing affordable quality seed to communities in a timely manner. The Integrated Seed Sector Development (ISSD) program is working with partners three agro-ecological zones to strengthen the development of a vibrant, pluralistic and market-oriented seed sector in Uganda. Since 2012, ISSD has supported 30 LSBs (approx. 900 farmers) producing and selling quality declared (QDS) seed of major food crops including beans and groundnut. In 2014, LSBs produced a total of 154 MT bean seed; contributing 3.73% of formal seed and 38 MT groundnut contributing 1.60% of formal seed use in Uganda. The QDS bean seed was sold at \$ 0.80 per kg, compared to \$ 1.20 for certified seed and \$ 0.60 for grain. The QDS groundnut seed was sold at \$ 1.30 per kg compared to \$1.81 for certified seed and \$ 0.83 for grain. QDS makes seed more affordable to small scale households and is more competitive to local market seed (grain) than certified seed. Additional income for smallholder farmers as a result of using legumes quality seed was \$ 19 per household for approximately half an acre. The return to investing \$ 3 extra in buying quality seed as opposed to using grain is \$ 22.85 extra value of grain produced.

Paper Number: 1280

Taking Cowpea to Scale in West Africa: A Business Model.

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(1) Statement of the problem or hypothesis IITA and partners have developed proven cowpea productivity increasing and post-harvest losses reducing innovations that are poorly adopted. This is due to a lack of awareness of innovations. Where knowledge on available innovations is sufficient, inadequate access limits their utilization. Improving end-users' access to proven innovation and their awareness of nutritious value of cowpea will increase adoption of cowpea innovations in target countries. This will increase productivity, production, home consumption and incomes. (2) Key findings making explicit how they address the problem or hypothesis The cowpea out scaling project has developed an advanced cowpea seed systems to produce, market and make available high quality affordable seed of improved and preferred cowpea varieties to smallholder farmers in project areas. Research institutions have been engaged to produce and make available to seed companies 3.8 tons of breeder seeds for the production of 52 tons of foundation seeds. Out growers, 436 community based organizations and 234 farmer organizations have been trained to produce 337 tons of certified/quality declared seeds and sale to their communities' members using innovative marketing strategy. A revolving seed system had been used at community level and 3,250 households' representatives have been trained on the nutritional value of cowpea. (3) Overall significance of the findings (results) to grain legumes and possible future research and/or development activities. A strong market oriented seed systems, information on the grain market and capacity building of key stakeholders are key to increase smallholders' farmers' adoption of new and proven innovations. The use of a strong seed revolving system and nutritional awareness campaigns will ensure a sustainable provision of high quality seeds to smallholders' farmers and increase home consumption of cowpea.

Paper Number: 1281

Approach to Catalyzing Early Generation Seed Systems for Legumes in Africa.

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2016 Joint World Cowpea and Pan African Grain Legume Research Conference

28 February to 4th March Livingstone Zambia

Abstract – Approach to Catalyzing Early Generation Seed Systems for Legumes in Africa

Problem

While a great deal of government and donor investment has been channeled into the promotion of agriculture in sub-Saharan Africa, the vast majority of attention has been devoted to traditional staple crops and cash crops. Legumes have historically been neglected. Low levels of attention to legumes is a missed opportunity to improve nutrition, lives, and livelihoods for smallholder farmers (SHFs) in Africa. There is a strong case for stimulating legume production and value addition in Africa. Legumes provide numerous opportunities to improve the lives of smallholder farmers and benefit local communities. The value of legumes for SHFs can be divided into three categories: income-generating opportunities, improved nutrition and health benefits, and soil and eco-system health. Despite the recent growth in legumes production within the focus countries, there are a number of constraints preventing SHFs from taking full advantage of the opportunities offered by legumes. In addition to barriers which farmers of other crops in Africa face, seven categories of legumes-specific constraints are apparent[1]. The greatest constraints exist in seed research and development, seed production, distribution and adoption, and market linkages between SHFs and large-scale legumes buyers. Particularly, the constraints to SHFs taking advantage of legumes seed varieties capable of resisting pests and drought and producing higher volumes of grain with more uniform and desirable characteristics run along two dimensions. Firstly, legumes seed research and development in the focus countries is limited due to a lack of funding available to research institutions and legumes being de-prioritized relative to staple crops. Secondly, and perhaps more critically, early generation legumes seed production and distribution infrastructure in focus countries is virtually non-existent. Since legumes seeds are recyclable and are viewed as less important than other crops, few private sector companies are willing to make the investments required to multiply and distribute seed, particularly in the breeder and foundation seed part of the value chain. Therefore, in a number of countries, the public sector / parastatals control the production and delivery of early generation seed. Limited technical and financial capacity of public sector enterprises only exacerbates the problem. In addition, the production and delivery of early generation seed is highly dependent upon interventions by development organizations such as USAID and BMGF. These interventions are much driven by supply, i.e. getting the materials out to seed producers to reach farmers, often resulting in dependency on external financial resources, and thereby limiting a demand driven and diverse structure of the seed value chain. When plant breeding is conducted by public entities, business models for breeder and foundation seed production and delivery are not straightforward. In short, the EGS ecosystem in the formal seed sector, particularly for Legumes, in Sub Saharan Africa is severely broken. There are many constraints to accessing publicly bred varieties, and the private sector often does not operate at sufficient scale to fill the gaps. One reason for this is that policies do not always support efficient models for scaling production and delivery of EGS. Seed policy is either too general, treating all EGS as a public good with heavy state involvement, or too specific, applying idiosyncratic policies for specific crops in specific countries or regions. What complicates the matter further is that the field of agriculture development is polarized in its views on private sector role in EGS - this often results in interventions and policies that are often based on deeply held beliefs and views backed by limited evidence. As a result, formal seed systems remain small, improved varieties are not effectively commercialized, and access to quality seed is limited.

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While the role of informal seed systems is important now and in the future, scaling the formal seed sector will be critical to increasing availability of quality seed of improved varieties.

Solution

To address this challenge, earlier this year, Monitor Deloitte worked with the United States Agency for International Development (USAID) and the Bill & Melinda Gates Foundation (BMGF) to develop an approach and a framework to help catalyze the Early Generation seed systems in Sub-Saharan Africa. The study was focused on improving agriculture productivity and livelihoods of smallholder farmers in Sub-Saharan Africa by promoting the development of a vibrant, pluralistic and market-oriented early-generation seed sector (including breeder and foundation seed). Specifically, Monitor Deloitte used an assessment of the production and delivery of early-stage seed sectors within five target countries (Ghana, Nigeria, Ethiopia, Tanzania and Zambia) and across six crops and pathways to sustainably improving the effectiveness of early generation seed systems to inform the study. The study was seminal in nature – it used an evidence based analytical approach to demonstrate the following:

- Approach to catalyzing early generation seed systems will need to vary by country-crop context. Often, the context could be characterized by two dimensions – Marginal economic value of quality seed of improved varieties and Level of monetized demand for varieties or crops grown with quality seed of improved varieties.
- Broadly speaking, most country-crop contexts could be classified into four market archetypes (Private, Publoc, Public-Private and Niche). Identifying which archetype does a particular country-crop combination is crucial for understanding and addressing the bottlenecks within those EGS systems. Empirically, it was observed that most country-crops fall into the Archetype 2 (Public-Private Collaboration) and that addressing bottlenecks would require significant amount of collaboration between public and private sector actors.
- The role of public and private sector actors across each of the market archetypes varies significantly (refer to Figure 2). Also, it is important to note that in order to identify the role of public and private actors across a particular value chain, a detailed assessment of economic incentives and operational capabilities is critical.
- At a country level, it is important for governments and donors to determine the role of private sector players across priority crops. This allows them to reallocate their resources across various crop types and to double down on crops that require significant government resources and attention
- Finally, the study also provided generalizable principles and recommendations to help guide key stakeholders as they pursue policies, investments, and interventions across each of the four archetypes. The recommendations across the various market archetypes are as follows:
 - In the public sector market archetype, the donors and governments need to improve the efficiency of public sector efficiency in early generation seed production and distribution. This includes building the capacity of public sector research institutions, and potentially exploring contract production arrangements with private operators
 - In the private sector market archetype, the role of governments and donors is to reduce distortionary regulations and policies that limit private sector participation on early generation seeds

In the case of the two public-private collaboration market archetypes, there is a need for governments and donors to identify ways to either mitigate demand risk or lower production costs by providing supply side subsidies for private players

Implications

The study and the recommendations were broadly socialized with the key stakeholders in the early generation seeds ecosystem by USAID and the foundation through a series of convenings and bilateral and multilateral consultations. The convenings and consultations have resulted in a broad based intent amongst key stakeholders to leverage the learnings from the study to develop robust country level plans to catalyze early generation seed systems across a number of countries. We believe that if the approach to catalyzing early generation seeds sector were to be adopted by countries across Africa particularly for the Legume crops, the potential for transformation would be immense. Not only would we see significant increase in availability of high quality seed to farmers but also at significantly lower levels of public/ donor investment. This would benefit millions of smallholders farmers improve their incomes, nutrition & health and soil health.

[1] African Legume Market Dynamics, Monitor Deloitte with support from Bill & Melinda Gates Foundation June 2012

Paper Number: 1282

Adoption of Cereal-Legume Intercropping and Improved Varieties in Post-War Northern Uganda: Impact on Crop Income and Labour Use.

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Cereal-legume intercrops and improved varieties are among agricultural interventions classified as “climate-smart”, particularly because of their important role to increasing productivity and enhancing resilience to climate variability. At farm-level, adoption of cereal-legume intercrops and improved varieties might present trade-offs. We study the impact of these interventions when implemented as a standalone and jointly on crop income and labour use. Data were collected from 585 households in which the principal male and female decision-makers were interviewed separately. Causal impacts of technology adoption were estimated by utilizing selectivity-corrected multinomial endogenous switching regression. We found that crop income increased by USD 85 per ha with intercropping only, USD 136.50 with improved varieties only; and USD 118.55 with joint adoption of intercropping and improved varieties. Adoption, both in isolation and combination, increased demand for male and female labour.

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Demand for female labour is higher than for male labour by 28% with intercropping only, 12% with improved varieties only, and 32% with both intercropping and improved varieties. The net gain from adoption, however, is positive implying that the increased income off-set the increased demand for labour. The paper discusses policy implications of the findings.

Key words: Cereal-Legume intercrop, improved varieties, climate-smart agriculture, trade-offs, Switching regression, Northern Uganda

Paper Number: 1283

Farmer Acceptability of a Bean Variety with High Iron Content: The Case of Icta Superchiva in Guatemala.

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From Guatemala's 14 million people, approximately 54% live in rural areas, 41% are indigenous, and more than half of its population lives in poverty (with 13% living in extreme poverty). Additionally, Guatemala is highly food insecure and with high levels of chronic malnutrition. The government and international cooperation are attempting to address these issues in various ways (e.g., industrial fortification, supplementation, biofortification). Thru biofortification, ICTA released Superchiva in 2014, which contains 40-50% more iron than traditional varieties and was widely disseminated in 2014 by the government and NGOs with the objective of promoting its use and consumption as to help to reduce iron deficiencies. Since the success of any given technology (e.g., improved varieties) depends on its acceptance by producers and consumers, this study evaluates the acceptability of this variety among a sample of beneficiary bean producers in eight departments of Guatemala, using primary data collected thru a household survey implemented in early 2015. The results suggest that while 74% of beneficiaries grew Superchiva because they wanted to test a new variety, only around 1% reported its nutritional benefits as the reason for growing Superchiva. Further, farmers replaced approximately 42% of their bean area with this new variety and roughly 76% of farmers reported they will grow this variety again the following season. These results suggest that the acceptability of this variety is good, but more needs to be done to reach more farmers and educate farmers about the biofortification benefits of this variety.

Paper Number: 1284

Updating the Atlas of Common Bean (*Phaseolus vulgaris*) Production in Africa: A Tool for Targeting and Evaluating Legume Research and Development.

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The adoption of grain legume technologies and practices by smallholder farmers in Africa is influenced inter alia by the biophysical fit of the legume technology or practice, the effectiveness of the research and extension service, and the producers' endowment of capital, land and labour. Successful dissemination of grain legume technologies and practices requires that these factors are considered and managed by spatial and socio-economic targeting. The Atlas of Common Bean (*Phaseolus vulgaris*) Production in Africa was a comprehensive assessment of the state of the bean production, marketing and consumption but was published in 1998 and is no longer able to provide reliable data for targeting. We have updated the atlas, taking advantage of new data and assessing new constraints and opportunities. We followed a Delphi method of consensus building with experts from 23 countries to review existing maps, secondary and primary data on bean production. PABRA Network coordinators, the monitoring and evaluation specialists, and GIS experts reviewed the evidence together with an average of 20 national experts per country to deliver over 150 different themes including: farm systems, variety diffusion, utilisation, markets, seed systems and constraints. Bean production areas often show stark contrasts with previous maps, underlining the value of canvassing background evidence on recent experiences and knowledge of a diverse range of research and development partners from different regions in any country. The methodology is potentially less accurate than more costly data collection strategies—such as household surveys—but produces more reliable results than from limited single key informant sources.

Paper Number: 1285

Impact of Improved Common Bean Varieties on Household Food Security on Adopters in Tanzania.

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Common bean (*Phaseolus vulgaris*) is the major grain legume grown in Tanzania; providing a source of food security and cash income. The crop is grown in diverse agro-ecological conditions, where productivity is severely constrained by several abiotic and biotic stresses. While growing of improved bean varieties introduced to increase and stabilize bean yields has increased over time, little is known about their contribution to the household food security.

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This paper evaluates the impact of improved common bean varieties adoption on daily per capita food expenditure and Household Dietary Diversity Score using binary and generalized propensity score matching techniques[1]. Results show a positive and significant average effect of improved bean varieties on the daily per capita food expenditure and household dietary diversity of adopters. Estimated treatment effects increase with the area allocated to the improved bean varieties but at a decreasing rate; leveling off at 4 acres level of adoption intensity. The study provides evidence of the economic benefits from bean research and allows researchers in seed system to design strategies for reducing seed access constraints and continuously support disseminate of new improved varieties to cope with changing environment especially by among small scale growers. The relevance strengthening monitoring and evaluation in legume research is also evident.

Key words: Common bean, household food security, Propensity Score Matching, Generalized Propensity Score technique

[1] We first used the binary Propensity Score matching to obtain treatment effects from the improved common bean varieties released after 2000 and then apply the generalized Propensity Score (GPS) approach to evaluate the effect of adoption intensity on the food security outcomes.

Paper Number: 1286

The IMPACT of Climbing Bean Adoption on the Welfare of Smallholder Common Bean Growers in Rwanda.

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Confronted with the challenges of land scarcity, Rwanda in collaboration with international partners has been promoting climbing bean in the country since 1984. The long term goal of this commitment is to increase food security and reduce poverty while sustaining the natural resource base. While numerous success stories have been told about the climbing bean in Rwanda, its impact on adopters has not been fully evaluated. This study assesses the contribution of climbing bean growing on the household economic well-being using four indicators: per capita bean consumption, household food security rating, per capita consumption expenditure and poverty. Results reveal a strong positive linkage between area under climbing bean and household bean consumption. Besides, for additional 10-kg of climbing bean seed planted, annual per capita expenditure increases by 14 percent; while the severity of poverty reduces by 0.4 percent points. Soil acidity, urbanization and land degradation reduce land area allocated to climbing bean. Findings demonstrate the effectiveness of bean production intensification, providing the needed ammunition for deciding on relative resource allocation to specific lines of research for improving food and nutrition security among land constrained households in East Africa sub-region. It informs scientists and the broader development community of the physical and socioeconomic factors that require consideration in further research for higher economic benefits.

Paper Number: 1287

Variety Release, Adoption, and Potential Impacts of Improved Cowpea in Sub-Saharan Africa.

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This paper analyzes the effectiveness of cowpea improvement programs in Sub-Saharan Africa using varietal release information and adoption estimates obtained from a survey of national programs in 18 countries, which together account for over 95% of the total cowpea production. The paper also estimates the potential economic benefits and rates of return on investment in improved seed systems aimed at enhancing adoption of new and promising varieties. Over the period 1970-2010, variety release has been unstable and slow in all the 18 countries surveyed. Nearly 200 improved varieties have been released and 172 of these are formal releases, but only 26 varieties are being grown by farmers. Over 70% of the improved varieties have been developed and released in West and Central Africa, with Nigeria, Benin, Niger, Ghana, Mali, Guinea, and Cameroon having the highest number of variety releases. Mozambique is the only country in the East and Southern Africa with more than ten varieties released. The results show that improved varieties accounted for an estimated 23% (or 2.7 million hectares) of the total cowpea area in Sub-Saharan Africa. IITA materials covered a total of 1.8 million hectares or 16% of the total cowpea area in Sub-Saharan Africa. The index of varietal turnover shows that old varieties are still popular in all of the countries surveyed and this indicates the need for promoting newer varieties with greater yield advantages and economic benefits. The results of the ex-ante economic analysis show significant potential economic benefits and rates of return on investment in improved seed systems aimed enhancing adoption of new and promising varieties.

Paper Number: 1288

The Impact of Improved Chickpea Adoption on Poverty in Rural Ethiopia.

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Utilizing three rounds of panel data we analyse the impact of improved chickpea adoption on poverty reduction in Ethiopia. We first estimate the determinants of improved chickpea adoption using a double hurdle model. We apply a control function approach with correlated random effects to control for possible endogeneity of access to technology transfer and improved seed. To instrument for these variables we develop two unique distance weighted measures of a household's neighbors who have access to technology transfer or improved seed. Second, we estimate the impact of area under improved chickpea cultivation on household income and poverty. We apply a fixed effect instrumental variables model where we use the predicted area under cultivation from the double hurdle model as an instrument for observed area under cultivation. We find that improved chickpea adoption significantly increases household income while also reducing poverty. The results are disaggregated by initial poverty status to explore whether the impact of adoption has been pro-poor. Adoption favoured all but the initially poorest households, who require additional support to benefit from improved chickpea varieties. However, there seems to be considerable potential for upscaling improved chickpea varieties for sustainable intensification in Ethiopia.

Paper Number: 1289

Assessing Access and Adoption of Common Bean Improved Varieties in Northern Zambia.

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The agricultural sector contributes between 13-20% of Zambia's Gross Domestic Product and about 67% to employment. Legumes contribute quite significantly to the livelihoods of smallholder farmers in terms of food security and income. The study provides estimates of the rates of adoption of improved bean varieties and also bridge information gaps and an analysis of access, adoption and diffusion of improved varieties, drivers of adoption, gender perspectives in bean production and marketing. Two types of data collection strategies were used; a desk review of information pertaining to bean production and a household survey of smallholder bean producers. Seven districts were purposively selected based on importance of the bean crop from two provinces; Muchinga and Northern which represent 86% and 78% of total area planted in each province, respectively. A two-stage cluster sample selection method was used. In first stage, villages were randomly selected from each district according to proportion of villages within selected districts. In the second stage, six households were systematically selected per village. Findings show that improved varieties are known and used by farmers in study communities but their extensive adoption remains highly constrained by seed accessibility problems. Because farmers in Zambia grow bean in variety mixtures, area allocated to seed of improved variety by early adopters continue to be small; consequently constraining the capacity of farmers to bulk sufficient seed and facilitate subsequent diffusion among themselves. Large scale seed multiplication investment will be needed to overcome seed accessibility constraints and quickly achieve wide diffusion.

Paper Number: 1290

Grain Legumes and Gut Health.

Kenneth Maleta, School of Public Health and Family Medicine, College of Medicine, University of Malawi*

Abstract not available

Paper Number: 1291

Grain Legumes and Gut Inflammation and Relationship to Nutrition.

Elizabeth Ryan, Colorado State University*

Abstract not available

Paper Number: 1292

Legumes and Macronutrient Nutrition.

*Christina Mukantwali**, Rwanda Agricultural Board

Abstract not available

Paper Number: 1293

Legumes and Micronutrients.

*Mercy Lugaho**, PABRA-CIAT

Abstract not available

Paper Number: 1294

Breeding Climate-Smart Cowpeas for West Africa.

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Cowpea (*Vigna unguiculata* L. Walp) is a vitally important component of the human diet in sub-Saharan Africa, the dry grain consisting of on average 25 % protein and 64 % carbohydrate, and its amino acids and minerals complementing those provided by cereals. However, the rainfed production of cowpea in the region, primarily by small-holder farmers, is several-fold lower than the known genetic potential for yield due to stresses from drought, heat, pests and diseases, plus low-fertility soils. Modern breeding technologies and genomic resources are being applied to introgress tolerance and resistance traits for major constraints, including for early season and terminal drought. Available new resources include SNP-based genotyping platforms, marker-dense genetic consensus maps, and QTLs identified for trait determinants across the cowpea genome. A team of advanced institution and African NARS geneticists and breeders is pursuing drought tolerance breeding in cowpea by application of these tools. The current positive progress in advanced breeding line yield under drought using MARS and MABC breeding approaches and the IBP-Breeding Management System program will be profiled to highlight both the genetic gain and the challenges under these breeding schemes. New genomic and breeding management resources offer opportunities to cowpea breeders targeting important traits in different production systems. The new varieties under development will feed into regional efforts for scaling up cowpea seed systems for access by small-holder farmers.

Paper Number: 1295

Enhancing Genetic Gain in Chickpea Breeding in Marginal Environments in Africa and South Asia.

*Rajeev K. Varshney**, ICRISAT

Chickpea (*Cicer arietinum*) is the second largest cultivated grain food legume globally. Terminal drought is one of the serious yield constraints that confer ca. 40% yield loss. A range of translational genomics approaches are being used to enhance genetic gain in chickpea breeding and develop improved chickpea varieties for enhancing food and nutritional security in developing countries especially in context of climate change. In this direction, as a part of several initiatives and strategic collaborations with several partners from different countries, large-scale genomic resources including draft genome sequence, re-sequencing of > 1500 chickpea lines, comprehensive transcriptome assembly, high density genetic and BIN maps, QTL maps as well as physical maps have been developed. For trait mapping, by using linkage mapping approach, a "QTL-hotspot" harboring QTLs for several drought tolerance related traits was identified on linkage group 04 (CaLG04). The "QTL-hotspot" has been successfully introgressed in several elite chickpea cultivars using marker-assisted backcrossing (MABC) approach and many introgression lines have shown higher yield as compared to recurrent parent. Realizing the importance of this region, efforts are also underway to fine map this region. Similarly, MABC has also been used for introgressing resistance to Fusarium wilt (FW) and Ascochyta blight (AB) in elite chickpea cultivars.

In parallel, by using genome wide association study (GWAS) approach, 335 significant marker-trait associations (MTAs) have also been identified. For a high-resolution GWAS and understanding the genome dynamics, re-sequencing of 3000 chickpea germplasm lines has also been initiated. In addition, ca. 1000 lines from multi-parent advanced generation intercross (MAGIC) population have also been sequenced at 2X-3X for mapping drought tolerance at high resolution. Furthermore, several functional genomics approaches such as RNA-seq, Massive Analysis of cDNA Ends (MACE) with parental genotypes of mapping populations as well NILs have provided some candidate genes for drought tolerance that are being validated through genetical genomics and/or TILLING approaches. Finally, genomic selection (GS) approach by phenotyping and genotyping a training population of 320 elite breeding lines is also being used. An overview on above mentioned approaches for enhancing genetic gains in chickpea in sub-Saharan Africa and Asia will be presented in the conference.

Paper Number: 1296

Modern Technologies to Access Common Bean Responses to Environmental Stress.

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Abiotic stress significantly affects crop production by reducing yield. To maintain the best possible yield, plant breeders must select for those traits associated with positive yield performance under the abiotic stress condition. Therefore, assessing appropriate phenotypes for thousands of lines in a timely manner is important. With this data, those regions of the genome associated with an important phenotype can be mapped, and effective markers from those regions can be developed for selection purposes by the breeder. New phenotyping methods are being developed that can be applied to any field condition including those under stress. Some of these assay the entire field at a single time point and collect a few data points, while other methods collect data for many more phenotypes but data collection can take several hours. Examples of these phenotyping tools will be presented and how they are being used with common bean will be discussed. Associations of phenotypic data collected and specific genomic positions will highlight the relevance of the approaches to future marker development.

Paper Number: 1297

Harvesting Climatic Adaptations from the Wild Progenitors of Chickpea and its Symbiotic Bacteria.

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We have collected and made public a large, novel source of natural genetic variation for chickpea improvement. Population genomic analysis of 1,100 wild accessions using genotyping-by-sequencing nominated a representative set of 20 wild genotypes for full genomic characterization, population development, phenotyping and breeding. Whole genome sequencing of wild progenitor and elite cultivated accessions reveals a massive shift in the extent and nature of genetic diversity. Modern elite genotypes retain less than 5% of wild diversity. This unusually strong domestication bottleneck is accompanied by both an enrichment of non-synonymous mutations (likely deleterious alleles) and a decrease in observed phenotypic variation in the elite cultivated materials. These observations suggest that the wild progenitors species of chickpea will provide a novel resource of agronomic traits not selected during the initial phase of domestication, including those for climate resilience. Our collection of wild accessions surveys the full ~100 Km² natural range of the species. In recognition of the importance of microbial communities to plant function, including tolerance of environmental extremes and environmentally-driven disease incidence, we are also characterizing microbial communities in natural settings and derived agricultural systems, using a combination of metagenomics and living collections. Pre-breeding in the crop has been initiated based on genotyping and phenotyping of a set of >90 recombinant inbred lines based on 20 wild donors and recurrent elite cultivars, which comprise an incipient association mapping population. Microbial resources are being deployed in field trials to improve inoculum for nitrogen fixation and for disease resistance screening.

Paper Number: 1298

Data Mining at Field Scales for Abiotic Stress via Photosynthesis.

*David Kramer**, Dan TerAvest, Kelvin Kamfwa, Donghee Hoh, Greg Austic, Sebastian Kuhgert and Isaac Osei-Bonsu, Michigan State University

Rapid and sustainable improvements in the productivity and robustness of agriculture are urgently needed to meet human food requirements and overcome entrenched poverty, especially in the developing world, which not only has the greatest food needs, but also lacks the sophisticated plant monitoring and analytical tools needed to apply cutting edge approaches to agricultural improvement. The talk will describe recent progress on the development and use of the PhotosynQ platform (www.photosynq.org), and an sophisticated yet inexpensive plant phenotyping sensor called MultispeQ, which aim to bring new high throughput phenotyping technologies to communities farmers, researchers, extension agents and entrepreneurs around the world, and thus provide the local tools, resources and actionable data that can guide the management and breeding of plants to improve the productivity and sustainability of agriculture. Recent results from a series of field trials in Africa (mainly in Malawi) and the U.S. show how data acquired by MultispeQ can be wirelessly saved to the PhotosynQ platform's cloud-based database and analyzed using big-data approaches, to provide early indicators of abiotic stress and crop yield. I will then discuss how the PhotosynQ approach may be used to aid in the development of local and global, data-driven and site specific best-bet management practices for farmers. I will discuss how the platform can be integrated with other approaches to identify trait loci that condition improved photosynthetic efficiency and resilience to abiotic stresses to augment plant breeding efforts.

Paper Number: 1299

Biological Control of Cowpea Insect Pests: Progress, Challenges and Opportunities.

*Manuele Tamo**¹, Barry Robert Pittendrigh², Srinivasan Ramasamy³, Elie Dannon⁴, Joelle Toffa⁵, Benjamin Datinon⁵, Clementine Dabire⁶, Amadou Laouali⁷, Haruna Braimah⁸ and Stephen Kwaku Asante⁹, (1) International Institute of Tropical Agriculture (IITA), (2) University of Illinois at Urbana Champaign, (3) AVRDC-The World Vegetable Center, (4) International Institute of Tropical Agriculture IITA, (5) International Institute of Tropical Agriculture (IITA), (6) Institut de l'Environnement et de Recherches Agricoles (INERA), (7) INRAN: National institute of Agricultural Research of Niger, (8) CSRI/CRI, (9) CSIR-Savanna Agricultural Research Institute

The Problem:

Cowpea is the most important grain legume in West Africa. Without insect control, however, the estimated average production loss could attain 3.8 million tons (equivalent to ca. 3 billion USD) every year. Synthetic insecticides can provide a quick relief to the insect pest problem. However, in most cases the negative side-effect (including environmental, human and animal health hazards, and the resurgence of insecticide-resistant pest populations) outweigh the benefits. Hence, there is a need for a more sustainable, science-driven pest management approach.

Key findings:

Using the case study of the legume pod borer *Maruca vitrata*, we are presenting progress, challenges and opportunities for the development and deployment of a 'biological control pipeline'. Biodiversity and population genetic studies have been carried out to guide the identification of novel biocontrol candidates from Asia, which have subsequently been assessed for their potential in sustainably reducing pest populations. Pre-release assessment studies have targeted critical questions such as potential impact on biodiversity and biosecurity in general, together with factors leading to successful establishment such as host finding capacity and intra-guild competition. Experimental releases of two *M. vitrata*-specific hymenopteran parasitoids *Therophilus javanus* and *Phanerotoma syleptae* have been carried out and first results are presented.

Outlook:

Releases of biocontrol agents will be scaled-out to areas where the presence of alternative host plants can assure the maintenance of both the target pest and its newly introduced natural enemies all year round. In long term, biocontrol agents will establish over wide areas without the need for further releases.

Paper Number: 1300

Precision IPM: Developing Robust Tool Sets from Research to Deployment.

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Cowpea represents an important protein source for many people in Sub-Saharan West Africa, especially those living in rural areas and under \$2 a day. The main limiting factor for cowpea production is a complex of pest species. There exists no "magic bullet" for the control of these pests, however, there does exist a "basket of technologies" that can be used in concert to minimize these pest problems. Many of these technologies are already available, at the final stages of development, are a result of a pipeline for continual solutions, require scalable educational components or a combinations thereof. Our guiding hypothesis is that with the advent of ICT technologies, that have deep penetration (even at the village level in Africa), precision IPM systems can be created and deployed, resulting in yield-gain impacts on cowpea cropping systems. The results of an almost decade long multi-country research efforts has resulted in emergent tools for precision IPM strategies in cowpea cropping systems. These are highly cost-effective approaches that are ready for scaling across West Africa. The approaches include a biocontrol agent pipeline, biopesticides that can be locally produced and a high throughput educational system called Scientific Animations Without Borders. These strategies are currently being integrated into App-based systems that allow for better decision-making strategies and ultimately for real-time deployment into the hands of farmers in their own languages.

Paper Number: 1301

The Contribution of the Breeding Pipeline Concept to Ecological Management of Field and Storage Pests in Grain Legumes.

Paul Kusolwa, Sokoine University of Agriculture*

Abstract not available.

Paper Number: 1302

Integrating Weed Management into IPM Systems.

Ernest Mbega, Ilonga Agricultural Research Institute*

Abstract not available.

Paper Number: 1303

Pesticidal Plants for Pest Management in Bean: Key Emerging Issues.

Kelvin Mark Mtei, Nelson Mandela African Institute of Science and Technology*

Abstract not available.

Paper Number: 1304

Efficacité De L'huile De Neem (*Azadirachta indica* Juss) Et Du Virus Multi-Nucleopolyhedrose, Mavimnpv Sur Les œufs De *Maruca Vitrata* Fabricius Foreuse, Des Gousses Du Niébé *Vigna unguiculata* (L.) Walp.

*Clementine Dabiré**, Institut de l'Environnement et de Recherches Agricoles (INERA)

L'efficacité de l'huile de neem et du MaviMNPV a été évaluée sur les œufs de *Maruca vitrata* Fab., en condition de laboratoire, comme alternative aux insecticides chimiques. Les œufs âgés de 12 heures ont été collectés dans les boîtes transparentes, dénombrés et traités avec différentes concentrations de solution d'huile de neem, du MaviMNPV et de leur combinaison. Ces œufs traités, comparés à des témoins non traités ont été soumis aux conditions suivantes : Les œufs traités et non rincés, les œufs traités et rincés 1 heure, 2 heures et 12 heures après application du biopesticide. Les taux d'éclosion des œufs et de mortalité induite par l'effet résiduel de chaque biopesticide sur les larves néonates ont été évalués. Les résultats obtenus montrent que l'huile de neem réduit le taux d'éclosion des œufs de 89% et le MaviMNPV de 84%. Leur combinaison entraîne une réduction du taux d'éclosion de 91%. Ces biopesticides ont également entraîné une mortalité des larves néonates de 100% pour l'huile de neem et pour le MaviMNPV combiné à l'huile de neem. Cette mortalité est de 60% pour le MaviMNPV seul. L'utilisation de ces biopesticides est discutée dans le contexte de la gestion intégrée des insectes ravageurs du niébé. Mots clés : *Maruca vitrata*, Huile de neem, virus, gestion intégrée.

Paper Number: 1305

Tolerance to Combined Low Phosphorus and Drought Stress in Small-Seeded Common Bean.

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Yields of common bean (*Phaseolus vulgaris* L.) in the tropics are severely limited by drought and phosphorus (P) deficiency, and co-occurrence of these stresses is especially devastating. This study tests the hypothesis that genetic tolerance can play an important role in addressing these stresses, both singly and in combination. Common bean lines developed under conditions of drought and low P stress in CIAT, Colombia were planted by agronomists of the Nicaraguan national bean program at two sites in Nicaragua with naturally low fertility and low rainfall. One site received 150 mm of rainfall and the second site only 85 mm in the crop cycle. No additional moisture was applied. At each site two fertility treatments of 0 and 40 kg of added P were established. In each trial the best line outyielded the elite local check widely: at the first site, 2455 versus 1361 kg/ha with fertilization, and 1859 versus 790 kg/ha without fertilization; and at the second site under severe drought, 808 versus 220 kg/ha with fertilization and 600 versus 140 kg/ha without fertilization, while local farmers suffered total crop loss. The line BFS 81 produced well at both sites, and under severe drought in a fertile Mollisol in Colombia. Yields of BFS 81 even under severe drought without fertilization were comparable to average on-farm yields in Central America. Assuring even 600 kg/ha under such severe conditions offers much greater food security, and can be of utility in regions of Africa with similar conditions of abiotic stress.

Paper Number: 1306

Morpho-Physiological Characteristics and Grain Yield Attributes of Selected Cowpea Lines Under Phosphorus and Moisture Stress Conditions at Ukulima Farm, Limpopo Province, South Africa.

Setshele Standford Thosago, University of Limpopo (Turfloop Campus), Funso Raphael Kutu, North-West University (Mafikeng Campus) and Irvine Kwaramba Mariga, University of Limpopo*

In South Africa, few cases of commercial cowpea production do exist primarily for fodder while the majority of smallholder growers cultivate the crop as vegetables that are commonly described as 'Morogo'. Besides the dearth of research on cowpeas as pulses, the problem of drought and widespread phosphorus (P) deficiency are common abiotic stresses that could potentially constraint grain cowpea production on many South African soils particularly, on smallholder farmers' fields. A field experiment was conducted at Ukulima farm during 2012/13-summer planting season to assess the response of eight selected cowpea lines to low soil P and moisture stress conditions so as to identify potential excellent genotype that adapt well to South African field condition. Treatments evaluated comprised of two levels each for soil P (low and high) and moisture status (water stress and well-watered); and eight cowpea genotypes (Tvu 4632, Tvu 6365, Tvu 9848, Tvu 15445, Tvu 16408, Tvu 15143, Oloyin and IT00K-1217). Low soil-P level implied available P measured in situ, which was less than 8 mg kg⁻¹ while the high P level entailed 40 kg P ha⁻¹ application rate. All treatment factors were combined as split-split plot arrangement fitted into randomized complete block design; with four replicates. Morpho-physiological parameters such as growth attributes, root traits, and photosynthetic parameters as well as grain yield were collected from the trial. Results revealed that cowpea plant height, number of branches, number of trifoliolate leaves per plant and grain yield under the two P rates differed significantly (P<0.05) among the cowpea genotypes. Among the morpho-physiological traits, stem diameter, tap root diameter up to 15 cm and basal roots had significant and positive correlation with grain yield.

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Significant P rates × moisture status interaction effects were observed on the mean number of trifoliolate leaves, lateral root density and grain yield. This suggests that elevated level of soil available P can help mitigate the negative effect of moisture stress through enhanced root growth and development. Such improvement could ultimately lead to enhanced water and nutrients uptake, plant growth and grain yields.

Key words: Dryland farming, food security, Grain cowpea, phosphorus deficiency

Paper Number: 1307

The Use of Cowpea Haulm to Reverse N and P Mining in the Dry Savannas of Nigeria.

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Cowpea is a key food legume in the cropping systems of the savannas of Nigeria. The use of improved dual-purpose varieties is an effective strategy for improving the income of farmers. However, the productivity of the dual purpose cowpea in the savannas of Nigeria is constrained by poor soil fertility and the alarming rate of nutrient depletion. Nutrient balance assessment was carried out to determine the effect of removal or retention of cowpea haulms on N and P partial balances. The study was conducted in 32 farms in the northern Guinea savanna and 20 farms in the Sudan savanna during the 2009 and 2010 cropping seasons. The nutrient inflows monitored were mineral fertilizers use, manure application and biological N fixation. The nutrient outflows assessed were crop produce harvesting and crop residue removal. The amount of N obtained from biological N fixation was 18 to 102 kg/ha in the northern Guinea savanna and 3 to 41 kg/ha in the Sudan savanna. The total removal of crop residues led to nutrient mining of -145 to -44 kg N/ha and -6 to -51 kg P/ha annually in the northern Guinea savanna. In the Sudan savanna, the nutrient mining was low and ranged -42 to -5 kg N/ha and -10 to 8 kg P/ha annually. Retention of cowpea haulm led to positive N and P balances in all locations. These results indicate the retention of cowpea haulm on the farm after harvest could reverse nutrient mining in the savannas of Nigeria.

Paper Number: 1308

Evaluating Performance of Maize-Bean Intercropping in Smallholder Farming Systems of Zimbabwe.

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Abstract

In many mixed cropping systems of Zimbabwe, maize is commonly grown in association with bush type beans. Opportunities exist to integrate climbing beans in such systems. However, few studies have been carried out to evaluate the performance of climbers in intercropping systems. Field experiments were carried out at Gwebi Variety Testing Centre, Harare Research Station and Cotton Research Institute, from 2011 to 2013 to determine the responses of bush type bean and moderate climbing type to intercropping with maize. A factorial experiment was laid out in a randomized complete block design with five treatments sole climber, sole maize, sole bush bean, intercrop climber/maize and intercrop bush bean/maize. The grain yield, Land Equivalent Ratios (LERs) and cost benefit analysis were used to compare the performance of the intercropping system. Grain yield for both bush (1068 kg/ha) and climbing (1123 kg/ha) bean types were significantly higher ($P < 0.001$) in monoculture than in the intercrop (bush 205kg/ha, climbing 440kg/ha).

The climbing bean/maize LER of 1.33 was higher than the bush bean /maize LER of 1.23 showing that more land is needed to produce similar yields when crops are grown in monoculture. The maize/climbing bean net income of US\$435 was higher than the net income of US\$242 intercropping bush/maize. The results suggest that intercropping maize with a climbing bean type is a better option than intercropping maize with the bush bean type and can be recommended to farmers.

Key words: mixed cropping, maize, bush bean type, climbing bean type, Land Equivalent Ratios, net income

Paper Number: 1309

Limiting Nutrients for Bean Production on Three Contrasting Soils in Uganda.

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Common bean (*Phaseolus vulgaris* L.) is one of the most important grain legumes but its yield has remained well below the genetic potential. Poor and declining soil fertility is considered the primary constraint to common bean production.

Farmers in the Lake Victoria crescent of Uganda have been using fertilisers to boost production, but with limited response. This is due to nutrient imbalances, the specifics of which are not known. The objective of this study was to determine the limiting nutrients in Phaeosem, Cambisol and Umbrisol soils for bean production. A nutrient omission study in form of CRD was laid out with three replicates and nine treatments: (1) Complete treatment, (2) N omitted, (3) P omitted, (4) K omitted, (5) Mg omitted, (6) S omitted, (7) Ca omitted, (8) Micronutrients omitted and (9) Control. Each treatment was randomly assigned to the three soils (Phaeosem, Cambisol, Umbrisol) commonly cropped to beans. Results indicate that Phaeosem had inherently greater fertility than the other two soils. Bean growth in the P omitted treatment accumulated 39.6% significantly less aboveground biomass than those grown in the complete treatment. Beans in the N omitted treatment had 14.5% significantly fewer leaves than those grown in the complete treatment. Phosphorus was the most limiting nutrient for bean production, followed by nitrogen in the three soils tested. Therefore, improved P and N availability likely will increase bean growth, development, and yield in the predominant soils in Masaka, central Uganda. Field studies are necessary to confirm that P and N addition, and source thereof, will improve bean production and economics.

Key words: Common bean, limiting nutrients, soil types

Paper Number: 1310

Determining Limiting Nutrients on GRAIN YIELD and YIELD Components in Common Bean (*Phaseolus Vulgaris* L.), UNDER Drought and NON-Drought Conditions.

MONEA LINA ADELINO MUCAVEA, Msc graduate Student*

Drought and soil fertility are some of the major factors limiting crop yield especially in crop legumes. Six on-station trials were conducted to determine nutrients limiting the grain yield and yield component in common beans (*Phaseolus vulgaris* L.) under drought and non-drought conditions at Kandiyani and Chitedze Research Station. Two trials were conducted at Chitedze Research Station central region of Malawi under rainfed conditions: one using a climbing bean variety (MAC 53) and another using bush bean variety (SUG 131). The trials were repeated at Kandiyani also in Malawi under irrigation: one set of bush and climbing bean (2 trials) were evaluated under adequate moisture up to physiological maturity and another set (2 trials) was evaluated under moisture stress by cutting the water supply soon after flowering to simulate terminal drought. The experiments were laid out in a split-plot treatment arrangement with 3 replicates. In each replicate 9, main plots (macronutrient factors) were allocated at random to each replicate, and within the main plot, 4 subplots (micronutrient factors) were allocated at random making a total of (9x4) 36 treatments in each replication. The macro-nutrient factors included: (1) control; (2) N; (3) P; (4) K; (5) Ca; (6) N₂-fixation –CIAT 899 Rhizobium (Rz); (7) NP, (8) NPRz; and (9) NPK. The sub-plots were: (1) control; (2) B; (3) Mo; and (4) ZnS. There were significant interaction among macronutrient and micronutrient on grain yield. Nitrogen, Phosphorus, Molybdenum with rhizobium inoculant (NPRz + Mo) resulted in significantly increased grain yield of beans, days to flowering, number, fresh weight of nodules number of pods and 100 seed weight. Across water regime analysis on climbing beans showed that the macronutrients application had highly significant effects ($P < 0.001$) on the number of days to flowering, number of pods per plant and grain yield per hectare, while macro-micronutrient combination had significant effect at $P = 0.005$ level on days to flowering and highly significant effect ($P < 0.001$) on the number of pods per plant. In terms of drought tolerance efficiency (DTE) and drought susceptibility, P fertilizer treatment was observed to influence high drought tolerant efficient (DTE) also with smaller percentage of reduction (2%) under drought stress. However, NPK + Mo treatment was the best with smaller drought susceptibility index (DSI) on bush beans. Under climber beans, N+P and N+P+Rz were observed to be the best with high drought susceptibility index (DSI) among the 36 treatments.

Paper Number: 1311

Determinants of Market-Orientation Among Smallholders: Evidence from Bean Farmers in the Northern Rwanda.

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Since 2000, efforts for agricultural development in Rwanda have been focused on shifting from subsistence to market orientation. So far, the information on how smallholder farmers are progressing is limited. This study aimed at contributing on the matter by analysing market-orientation status and its determinants among bean producers. A total sample of 256 bean farmers from the Northern Province were interviewed using a structured questionnaire. A double-hurdle model was used to identify the determinants and extent of participation. It considered market-orientation as a twostep process involving farmers' market participation first and then, their degree of participation. Results indicate that 30% of the farmers participated in the market while 70% produced for home consumption only. The average commercialisation index for beans was 0.42 among those who participated. The estimation of a double-hurdle model showed that a one year increase in schooling years and one unit increase in land size would increase the probability of selling by 7% and 2%, respectively. With respect to extent of market participation, a unit increase in education, price of beans and participation in wage employment would increase the degree of market-orientation by 1.3%, 0.1% and 1%, respectively. Subsistence farming still dominates among bean producers though progress towards market-orientation was also noticed. A way to boost market-orientation is through farmers' access to education (e.g. adult learning) and rural employment creation.

Key words: Market-orientation, Commercialisation, Beans, Double-hurdle, Rwanda, Farmers

Paper Number: 1312

Socio-Economic Assessment of Chickpea Production, Technology Adoption and Market Linkages in Ethiopia.

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Chickpea has recently emerged as a strategic commodity in the commercialization of Ethiopian smallholder farming systems. Accounting for nearly 2.5% of world and 55% of Africa's chickpea production, Ethiopia belongs to the top-10 global chickpea producing countries. Despite its potential, Ethiopia's global market share is less than 4%. Tropical Legumes II (TL II) project was launched in 2007 with the major objective of increasing the productivity and production of chickpea in Ethiopia by developing farmer and market preferred improved chickpea varieties and securing seed access by smallholder farmers. Data generated from the baseline survey including the subsequent two early adoption surveys showed that significant success was achieved during the two phases of the project (2007-2014). During the baseline in three pilot project districts, 76% of the total chickpea area was covered by local varieties while the two improved chickpea varieties Arerti and Shasho were planted on 10 and 21% of the total chickpea area, respectively. Within 3 years, the share of local chickpea area shrunk to 33% while the share of Shasho and Arerti increased to 40 and 18%, respectively. At the end of the second phase of TL II, the chickpea area covered with improved varieties has reached nearly 80%. Cost-benefit analysis of improved chickpea production technologies in major chickpea growing areas indicated that chickpea is more profitable than other input intensive cereals such as wheat and tef. Besides, chickpea sector has an important gender dimension in terms of participation, access to and control over resources.

Paper Number: 1313

Contextual and Factual Analysis of Common Bean Production, Consumption and Marketing and Bean Attributes That Affect Demand for Bean Consumption in Malawi.

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Common beans are recognized as an important source of income for smallholder farmers as well as a good and cheap source of protein. However, a lot of changes have taken place in legume production and consumption patterns and further empirical research on bean production, marketing and consumption levels lack in Malawi. Considering the importance of beans in enhancing household incomes through trade and nutrition through consumption empirical research could reveal the current situation and bean attributes that determines of consumer demand.

Besides the situation analysis this study uses a more robust estimate (Mixed Logit) to analyze how a combination of bean attributes affect the demand of beans for consumption. The study analyzes activities in the upper part of the bean value chain to feed to the lower part of the value chain. Results show that common bean production ranks second from pigeon peas with the central region of Malawi producing most. In terms of production by gender, male-headed households lead production. Most consumption of beans is observed in rural households compared to urban and preferred color is molted beans. Furthermore, most of the beans were sold, followed by stored for seeds, then consumed. Further results show that access to credit, access to extension and volumes of previously sold beans positively influenced common bean production. Common bean breeding and production should address consumer (market) needs to gain economic value of efforts. Farmer production could be enhanced through access to extension, credit and markets to reduce poverty and malnutrition.

Paper Number: 1314

IPM Intervention in Benin: Cowpea Farmers' Preferences for Biological Versus Chemical Pest Control Strategies for *Maruca Vitrata*.

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Cowpea-producing households in West Africa face severe food security challenges due to enormous yield losses associated with major pests such as *Maruca vitrata*. Farmers respond to pest attacks by applying broad spectrum synthetic pesticides often without following recommended application rates. Although chemical pesticides have been instrumental in global crop protection efforts, persistent and indiscriminate application make them expensive and unsustainable for resource-constrained farmers. Moreover, chemicals pose serious health and environmental hazards. Therefore, it is critical to explore more sustainable pest control alternatives such as parasitoids and plant-based biopesticides as components in integrated pest management strategies. Biocontrol does not require high investments by farmers and has been shown to be safe for humans and the environment. Consequently, it is critical to predict potential adoption by understanding factors that explain farmers' pest control decisions. Employing Random Utility Theory, we designed and implemented a choice experiment survey for 505 cowpea farmers across Benin. Survey findings indicate that farmers are aware of health hazards posed by chemical pesticides but continue to use them out of necessity. Choice model results reveal that significant factors driving pest control decisions include pesticide cost, application labor requirements, and potential yield loss. Finally, increased community participation in the biocontrol program enhances other farmers' likelihood of adoption. Our research has promising implications for the cowpea sector in West Africa in terms of developing and disseminating sustainable biological pest control strategies that are cost effective, and eco-friendly. Furthermore, this research contributes to achieving household food security and protecting public health.

Paper Number: 1315

Determinant of Purchase Decision for Quality Declared Bean Seeds in the Central Northern Zone of Tanzania.

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Like in other African countries, beans in Tanzania are important source of dietary protein as well as source of income for many rural and urban households. Nonetheless, production of bean crops in many parts of the country has been limited by lack of quality seeds. Therefore, Tanzania adopted Quality Declared Seeds (QDS) production system in order to promote quality seeds use, yet QDS accounts for relatively very small amounts of seeds sales in the country. The objective of the study was characterization of limiting factors to acquisition of QDS bean seeds, with specific emphasis on the identification of factors which influence purchase decision of QDS bean seeds amongst the farmers. A sample of 134 bean grain producers in Karatu district in Arusha and Babati district in Manyara was used to generate information. Standard logistic regression was employed to determine factors that influence the purchase of QDS bean seeds in the study area. The results suggested that, age of household, agriculture training, extension service contact, income and membership in credit society were the major factors influencing purchase decision of quality declared bean seeds ($p < 0.05$) among the farmers. The study recommends improvement of agriculture training and extension service in order to create awareness and hence increase purchase decision of QDS bean seeds. The results also suggest that, membership in credit society may stimulate the likelihood of farmers to purchase QDS bean seeds in the study area.

Key words: Quality Declared Seeds (QDS), Bean(s), Purchase Decision, Tanzania.

Paper Number: 1316

Can Improved Food Legume Technologies Increase Technical Efficiency in Crop Production? a Case Study in Bale Highlands, Ethiopia.

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Abstract

This paper presents the impact of improved food legume technologies on technical efficiency of crop production in a farming system where mono-cropping of cereals is the way of life. Data on 600 randomly selected farm households were collected and plot level input and output data were generated on food crop production. We estimated technical efficiency of food crop production using a stochastic frontier model and the impact of food legume technologies on the efficiency using both discrete and continuous treatment effects models. High level relative technical inefficiency was observed among both adopters and non-adopters of improved food legume technologies. Nonetheless, farm households using improved food legume technologies were found to be less technically inefficient compared to those who are not adopting the technologies. Given the predominance of cereal mono-cropping in Bale highlands of southern Ethiopia, the development and deployment of improved food legume technologies could have far reaching effect on agricultural sustainability.

Paper Number: 1317

A Strategy for Geographic Targeting of Climbing Bean Varieties and Practices in Africa.

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Rainfall and temperature variability from global climate change are likely to be the two most important constraints to food production and to meeting increased food demand from growing population over the next decades in Africa. The research and development community working on common bean has developed technologies and practices that could be important for addressing these problems. Efforts made to improve yields and adoption of climbing beans has been one of the most important developments. These climbing beans can triple yields and are particularly important where land pressures make agricultural intensification a viable option. The Pan-African Bean Research Alliance (PABRA) has shown that new heat tolerant climbing bean varieties and associated agricultural practices can be expanded to the medium and low altitude (non-traditional climbing bean zones) and adopted under the right conditions. Given these developments and the pressures bean farmers in Africa are facing, what might be the elements of a strategy to scale up climbing bean adoption to areas across Africa that have not yet taken advantage of the potential of climbing beans? In this paper, we predict the potential suitability of climbing beans for 14 countries in sub-Saharan Africa based on known distributions of climbing bean varieties. We address the potential impact of increased temperatures and of how heat tolerant climbing beans could address the constraints posed by climate change. Using this information and the long experience of the PABRA network, the paper discusses the elements of a strategy to promote wider adoption of climbing beans in Africa.

Paper Number: 1318

Pigeonpea Water Use Efficiency Under Different Cropping Systems in Ghana and Mali.

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Abstract

Soil moisture availability is a major limiting factor to crop production in dry environments. The distribution of water in the soil profile and the proportion in the root zone for plants use is very crucial to crop production in these environments. Increasing crop yields will require the use of crops with deep rooting system and the potential of soil moisture extraction. There is often variation in water use efficiency within cultivars of the same plant due to different biomass allocation and rooting patterns, and cropping systems effects. In this study, our aim is to test the hypothesis that medium duration pigeonpea (*Cajanus cajan*) will have higher water use efficiency than long duration pigeonpea due to its faster growth, and to identify the characters which may contribute to these differences. Field studies were established at three different agroecological zones in Ghana and Mali using a randomized complete block design with 10, 12 and 14 treatments respectively. Two cultivars of pigeonpea, long and medium duration and sorghum (*Sorghum bicolor*) were planted as intercrop and sole crops. Changes in soil moisture content over the growing season in all cropping systems will be monitored using Time domain reflectometry (TDR). Access tubes were installed within the rows of plants to a depth of 100 cm in all treatments. Leaf chlorophyll content, grain yield and biomass will be measured at the vegetative, flowering and physiological maturity stages of the crop growth.

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Plant water use efficiency will be calculated as the ratio of biomass increase and water use over the growing period. Preliminary results on pigeonpea growth across study locations indicate Samanko site in Mali had the fastest pigeonpea growth. Data will be analyzed with the SAS statistical package (SAS Inc, 2002). Differences between cultivars and cropping systems will be analyzed by two-way analysis of variance (ANOVA) and LSD will be used to separate treatment means. Results from this research will help identify which pigeonpea cultivar is water use efficient and adaptable to smallholder farming systems in West Africa.

Paper Number: 1319

Below and Aboveground Pigeonpea Productivity in Doubled-up Legume Cropping Systems Across Three Agro-Ecologies in Central Malawi.

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Smallholder farmers in Malawi face many challenges which include a degrading soil resource base. Pigeonpea is one legume that has shown promise in Malawi in terms of improving soil fertility but its below and aboveground productivity is not fully understood. On-farm trials were set-up in 2013/14 across three agro-ecologies in central Malawi. Pigeonpea was planted as a sole crop or in an additive intercrop system with soyabean, groundnut or maize (farmer check system). The objectives of this study were to (1) assess the effect of cropping system and soil texture on pigeonpea root and shoot biomass and (2) to evaluate variability of pigeonpea growth within a smallholder farm context. Destructive harvest was conducted six months after planting to evaluate shoot parameters, and roots of the same plants were excavated from 0– 60 cm. Cropping system and soil texture effected shoot and root biomass ($P=0.05$). Sole pigeonpea had the highest shoot biomass at 11.83 Mg/ha, root at 1.56 Mg/ha and pigeonpea/maize had the lowest shoot at 3.57 Mg/ha root at 0.53 Mg/ha. Root biomass was largely confined to the topsoil, with trends similar to that for aboveground biomass. The results confirm that intra-specific competition in a pigeonpea/maize intercrop is large, while pigeonpea productivity in pigeonpea/groundnut intercrop is comparable to sole cropped pigeonpea, with additional groundnut grain benefits. Promoting the later cropping system can enhance land productivity on smallholder farms in Malawi. However, further research is needed to evaluate combined shoot and root biomass of all crops involved in the pigeonpea-based intercrops.

Paper Number: 1320

Effect of Variety and Location on Seed and Straw Yields and Nutritive Value of Common Bean (*Phaseolus vulgaris* L.) Straw in Crop-Livestock Systems of Ethiopia.

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Crop residue (CR) left after grain/pod harvest contributes substantially to the feed supply for ruminants in mixed crop-livestock systems of East-Africa, particularly during the dry-season. Little emphasis has been given to improving the yield and nutritive value of CR/straw for ruminants through plant breeding and selection without reducing grain/seed yield, particularly for grain-legumes. This study was carried out to explore the potential to simultaneously improve seed yield, CR yield and CR quality. Nine popular varieties of common bean (*Phaseolus vulgaris* L.) were grown at two locations (Boricha and Mandura) in 3m x 4m plots using a randomized complete block design with three replications during 2013/14. There was considerable variation among varieties in yield of total biomass, seed, and straw; harvest index (HI); leaf:stem ratio; ratio of seed weight to unshelled pod weight and CR nutritive value. Genotypes x location interactions were detected for all of these parameters except for HI. Seed yield was positively associated with straw yield for data combined across both sites ($r=0.79$; $P<0.001$; $n=54$). Straw quality and yields of straw and seed were unrelated at Boricha. However, there were negative relationships between straw quality and seed/straw yields at Mandura. These results indicate that the absence of straw quality penalty for high seed and straw yields in common bean can depend on location/environment. It should therefore be possible to identify varieties of common bean that combine high HI and straw yield with desirable straw quality characteristics to improve feed availability for ruminants in crop-livestock systems in East Africa.

Paper Number: 1321

Sustainability of Crop Residue Allocation Options in Smallholder Cereal-Legume-Livestock Farms in the Dry Savannas of West Africa.

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Crop residues are vital resources for improving the productivities of cereal-legume-livestock systems in savannas of West Africa. The keen demand for crop residues as fodder, constraints the use of crop residues as soil amendment. To enable farmers make informed decisions on the allocation of crop residues, an agricultural sustainability index was used to evaluate the ecological benignity, economic viability and social acceptability of five crop residue allocation options at Cheyohi (Guinea savanna), Sarauniya (Sudan savanna) and Garin Labo (Sahel savanna). The crop residue allocation options were: 0, 25, 50, 75 and 100% of haulm with 0, 75, 50, 25 and 100% of stover, respectively, as soil amendment or fodder. The most environmentally friendly options were the allocation of 75% haulm and 25% stover as soil amendment at Cheyohi and Garin Labo, and the total retention of crop residues at Sarauniya. The allocation of 25% haulm and 75% stover as soil amendment was the most economically viable option at Cheyohi and Sarauniya. At Garin Labo however, the removal of all crop residues for use as fodder was the most economically viable option. The total retention of crop residues on field while being the most acceptable option to farmers at Cheyohi, was the least acceptable option to farmers at Sarauniya and Garin Labo. The study brought to the fore the need to include economic and social parameters in the evaluation of agricultural technologies, as agronomic effectiveness alone does not determine the actual usefulness of a technology to a farmer.

Paper Number: 1322

Crop-Livestock Interactions in Cereal-Legume Cropping: Maize and Cowpea Population Effects on Crop, Livestock and Soil.

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Seasonal shortages in feed and low soil nutrients constrain increased productivity in small-scale crop-livestock farming systems in the West Africa. A better integration of crop and livestock production through cereal-legume cropping could address the constraints, but data is limited on the effect the population of either the cereal or legume component in a cereal-legume inter-cropping on grain and fodder yields, soil properties, and performance of sheep grazing the stubble. A 3-year study, using a randomized block design with four replications was conducted at Ibadan, Nigeria to test the hypothesis that the population of either maize or cowpea in a maize-cowpea intercrop will have no significant effect on grain and fodder yields; soil organic carbon (OC), total nitrogen (N), available phosphorus (P); and average daily gain (ADG) and fecal N and P contents of sheep grazing the stubble. Four cropping systems were compared: 54,000 maize plants ha⁻¹; 160,000 cowpea plants ha⁻¹; 40,000 maize plants ha⁻¹ intercropped with 40,000 cowpea plants ha⁻¹; and 27,000 maize plants ha⁻¹ intercropped with 80,000 cowpea plants ha⁻¹. The intercrops had higher Land Equivalent Ratio than the pure stands. The population of cowpea in the cropping system was linearly correlated to soil OC, N and P; and non-linearly correlated with the ADG, fecal N and P concentrations of West Africa Dwarf sheep grazing the stubble. Maize-cowpea intercrop with cowpea and maize population ranges of 40,000-64,000 and 21,000-42,000 plants ha⁻¹ respectively could increase total productivity of small-scale crop-livestock farming systems in the West Africa derived savanna.

Paper Number: 1323

The Characteristics of Extrusion Processed Foods from Whole Pigeon Pea.

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Pigeon pea is a nutritious (starch: 50%, Protein: 22%, Dietary fibre: 23%) yet underutilised legume due to its hard to cook nature and the presence of anti-nutritional factors. The overall aim of this research is to demonstrate that this legume can overcome these limitations through pre-treatment and extrusion processing thereby increasing use in food manufacturing. Seeds were submitted to (i) hydrothermal or (ii) alkaline (Sodium Bicarbonate) pre-treatment @ 90°C for 5 minutes followed by (i) wet milling or (ii) convection oven drying (50°C) and dry milling. To assess the impact of pre-treatment on extrudate characteristics, native (un-treated) seed was also processed. A twin screw extruder was utilised at a range of screw speeds (300-400rpm), feed rates (8-14kg/h) and temperatures (120°C -140°C). Hydrothermal pre-treatment followed by wet milling gave a cold-swelling product in contrast to hydrothermally treated seeds that were first dried and then milled, and the native seeds. A possible application for this cold-swelling product is as breakfast meal not requiring cooking.

Alkaline pre-treatment followed by drying and milling lead to the highest expanded products which were crunchy and may be consumed as ready-to-eat snacks. The high moisture content untreated feed produced extrudates resembling half products requiring further processing prior to consumption. In addition to the extrusion results, in-depth analysis of the extrudates' nutritional values, DSC-thermal analysis, X-ray diffraction, RVA-stirred viscosity, SDS-PAGE protein profile and microstructure were carried out. This research has devised promising approaches for the utilisation of pigeon pea in food manufacturing in Africa facing food security challenges.

Paper Number: 1324

An Assessment of the Canning Bean Value Chain in Kenya: Opportunities and Challenges.

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For the last 60 years, the canning industry in East Africa has relied on one particular variety – Mexican 142 – developed in the 1950s and released initially in Tanzania (1940s) and later in Kenya (1960s) and subsequently in Ethiopia (1970s). Over the years this variety has succumbed to diseases such as rust, angular leafspot, bacterial blight and recent frequent drought conditions. It has become uneconomical to produce this variety especially in Kenya and many farmers have abandoned its production. The industry has faced serious problem of acquiring adequate quantities of beans for canning and often operate below installed capacities. A study was carried out to assess the status of canning bean production, processing and consumption in Meru, Nairobi and Nakuru Counties of Kenya. Out of the 45 respondents supplied with seed by a processing company, 98% stopped planting the canning bean after the first season citing lack of market, low prices, diseases and poor yields as major reasons for ceasing production. Poor quality of navy beans purchased was cited as the major challenge facing bean processors. Only 11% of the 47 respondents said that they consumed canned bean. Majority of canned bean consumers were aged between 18 and 35 years. There is need therefore to promote the released canning bean varieties and carry out sensitization campaigns on consumption of canned or precooked beans which could lead to saving the environment because less fuel will be used.

Paper Number: 1325

Modelling Legume Soaking and Cooking Processes to Control Their Nutritional Value: Case of Chickpea.

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Traditionally, legumes such as chickpeas are first soaked (time-consuming step) in order to remove some contaminants and anti-nutritional factors. Then, a cooking step in water is carried out during which vitamin thermal degradation occurs together with starch gelatinization due to heat and water uptake. The extent of these physicochemical phenomena strongly depends on processing conditions and needs to be controlled. Using a combined experimental and modelling approach, chickpea soaking-cooking process has been described and optimized to maximize its nutritional value while reaching a sufficient degree of cooking and reducing preparation time. Tyson chickpea cultivar was studied for soaking temperatures and soaking times ranging from 15 to 25°C and from 12 to 24h respectively, followed by a cooking step at 100°C for 20, 30 or 60 minutes. Initial vitamin B9 content of chickpea was 149.7 ± 5 g/100g (db). The model was in good agreement with experimental water content, starch gelatinization and folic acid losses data. Both soaking and cooking times were found to dramatically impact vitamin B9 degradation. The optimal soaking and cooking conditions were found to be 20°C/18h and 100°C/30 min with maximum vitamin retention of 67% and a sufficient degree of cooking (starch gelatinization) of 85%. This mechanistic approach can be adapted to a wide range of legumes undergoing nutritional losses and other critical physicochemical reactions during processing (protein denaturation, anti-nutritional factor degradation...) and can be used as a monitoring tool to optimize their nutritional and organoleptic properties. Such research strategies provide good opportunity to promote the use and consumption of local cultivars which have high nutritional potential.

Paper Number: 1326

Physico-Chemical Characterisation of Some Cowpea Varieties Consumed in Botswana to Study Their Efficacy As a Protein Source in Infant Food Formulations.

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Leguminous seeds are an important part of the diet of rural communities in developing countries as they provide proteins, lipids and carbohydrates. However, the use of legumes is restricted by a number of factors, including the presence of flatulence causing carbohydrates, hard-to-cook defect (HTC) and extended cooking times. Cowpea (*Vigna unguiculata*) is a common legume in Botswana and widely grown by farmers in comparison to other legumes. However, not much information on the physio-chemical characteristics is available on cowpeas grown in Botswana.

A project was carried out to study physico-chemical properties of three commonly grown and widely acceptable cowpea varieties, namely Black eye, Tswana and IT95K-635-2. The three varieties were similar in proximate composition, except for crude protein, which was lesser (at 4% difference) in one variety. Their functional properties were also similar, which included bulk density, water absorption capacity and oil absorption capacity. There were also small differences in the cooking time of the three cowpea varieties. The fact that the three varieties were similar in physico-chemical properties suggest they can equally be used in the same types of food applications. The significance of the study is that it provides new knowledge which will affect the processing technologies using the varieties especially in the formulation of composite flours for infant foods and snacks, which is the next face of the project.

Paper Number: 1327

Chemical Composition, Functional Properties, and Cookie-Baking Qualities of Dry Bean Powders from 25 Michigan-Grown Varieties.

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Despite the great nutritional value of edible dry beans, factors such as long cooking time and unpalatability of whole beans hinder their consumption by humans. Processing beans into various value-added food ingredients could be an effective approach to enhancing their food applications. In this study, 25 varieties of edible dry beans grown in Michigan were ground into coarse (particle size <1.0 mm) or fine (< 0.5 mm) powders, and their chemical composition, functional properties, and cookie-baking performance were evaluated. Protein and starch contents of the beans varied between 19.1 and 26.6% and 34.4 and 44.5% (db), respectively. DSC thermograms of bean powders (BP) showed two peaks: Peak I mainly corresponded to starch gelatinization and Peak II to protein denaturation. Fine-BP displayed a higher final viscosity than coarse-BP for the same variety. After blending BP with commercial cornstarch (bean:starch=70:30, db), each blended mixture was used for cookie baking (AACCI Method 10-54). Generally, cookies baked from fine-BP blends had smaller diameters (range 7.13-7.85 cm), greater thicknesses (0.96-1.13 cm), and greater hardness values (14.03-29.25 N) than their counterpart cookies from coarse-BP blends (8.48-9.53 cm, 0.63-0.88 cm, and 5.40-13.61 N, respectively). Cookies baked from both BP blends had similar or larger diameters (7.1-9.5 cm), and higher protein (7.2-10.1%) and resistant starch (5.1-12.1%) contents than the soft wheat flour cookies (7.9 cm, 6.0%, and 0.8%, respectively). This study demonstrated that bean powders could be used to replace wheat flour for the preparation of cookies of comparable size and textural properties but greater nutritional value.

Paper Number: 1328

Versatility of Bambara Groundnut for Food and Nutrition Security.

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Bambara groundnut (BGN) [*Vigna subterrenea*] is an indigenous African crop; the seed containing 49–63.5% carbohydrate, 15–25% protein, 4.5–7.4% fat, 5.2–6.4% fibre, 3.2–4.4% ash and 2% mineral. It is a good source of fibre, calcium, iron, potassium and unusually high in methionine, an essential sulphur-containing amino acid. Yet this ancient grain has been underutilised. It is thus important to uncover the potential of this ancient grain. Network analysis indicated that BGN's seeds, flour (BGNF), therapeutic, functional and protein content control the value of BGN with betweenness centrality of 443.8, 257.2, 278.6, 198 and 141.8, respectively. BGNF stabilised emulsion was characterized as highly spreadable, thixotropic and highly rigid. BGNF can be used in food products alone or partially substituted with wheat flour as well as meat analogue. BGN milk (BGNM) supported the growth of probiotics producing a cultured beverage similar to yoghurt. BGN insoluble fibre (BGNIF) is high in phenolics (6.14–15.56 mg/g GAE) with higher swelling capacity compared with commercial fibres. BGN soluble fibre (BGNF) is galactomannan hydrocolloids similar to locust bean gum. All BGN fibres, especially the soluble fibres, possess higher fat absorption capacity than pea fibres. These value-added products confirm BGN as a legume with potential for food and nutrition security. Commercialisation of BGNM and its cultured milk is underway as products with promise of food and nutrition security through product innovation, job creation and improving livelihood of the rural poor who depend on BGN for sustenance.

Paper Number: 1329 (Poster Number: 201)

Effect of Nitrogen and Phosphorus Fertilizer MICRO-Dosing on the Growth and YIELD of Maize-Pigeonpea Intercrops in Tanzania.

Paul Sabas Saidia 1, Cornel Lawrence Rweyemamu 1 and Anthony Anderson Kimaro 2, (1)Sokoine University of Agriculture (SA), (2)International Centre for Research in Agro forestry (ICRAF)*

Declining soil fertility and poor soil moisture conservation methods are among the causes of low crop productivity by small scale farmers. The influence of nitrogen and phosphorus micro-dosed in maize-pigeonpea intercrop patterns grown under different soil moisture management practices were studied in sub-humid conditions of Tanzania.

The experiment was conducted in Changarawe (06o54 55.5 S and 036o57 11.6 E) and Ilakala (07o08 07 S and 036o55 12.6 E) as split-split plot design. The main plot being moisture management (tied ridge, open ridge and flat cultivation), sub-plots involved cropping patterns (maize sole crop, pigeonpea sole crop and maize-pigeonpea intercrop), while the sub-subplots were fertilizer use (NOP0, NP micro-dose and recommended NP). Fertilizers di-ammonium phosphate (18%N and 46% P2O5) and urea (46%N) were applied. Maize TMV1 and Babati white pigeonpea varieties were grown. Fertilizer micro-dosing in tied ridges under intercrops increased maize yield from 865 to 1580 and 869 to 2018 kg/ha while pigeonpea was 984 to 1118 and 410 to 151 kg/ha in Changarawe and Ilakala respectively. In flat cultivation, maize yield under micro-dosing fertilizer was 825 to 2050 and 1089 to 1705 kg/ha while pigeonpea yield was 1461 to 2661 and 449 to 290 kg/ha in Changarawe and Ilakala respectively. Fertilizer micro-dosing increases crop yields under adequate soil moisture when applied at proper growth stage. Although there is resources competition in maize-pigeonpea intercropping pattern which reduces yield but land use, nutrition and economic benefits are high. Therefore, fertilizer use at appropriate crop growth stage under proper soil moisture conservation practice in maize-pigeonpea intercrops is important under current climate change effects and poor soil fertility to improve crop yields.

Paper Number: 1330 (Poster Number: 202)

Evaluation of Cowpea Genotypes for Drought Tolerance in the Semi-Arid Environment of Botswana.

Odireleng O. Molosiwa and Bose C. Makwala, Ministry of Agriculture*

Drought is one of the major constraint to cowpea production especially in semi-arid environment prone to drought. The absence of high yielding and drought tolerant varieties are some factors that contribute to low level production of cowpeas in Botswana. Twenty four genotypes (12 exotic and 12 local lines), advanced and pre-released lines from various field experiments since 2007 were selected for drought tolerance. Three testing techniques were explored, at the Department of Agricultural Research for two seasons of 2013/14 and 2014/2015. A field assesment under rainfed, rain-shed glasshouse and a box-pot testing of genotypes was conducted. A rain-shed experiment was done with two levels of water applied (irrigation and non-irrigation) to substantiate the intensity and duration of drought on the growth and yield of selected cowpeas. A combination of the three testing techniques proved useful and reliable. Irrigated and non-irrigated genotypes were significantly different at ($P < 0.01$) in most of the traits with a few exceptions like 100 seed weight. A comparison based on seeds per plant between exotic and local lines revealed that IT95K207 was significantly different ($P < 0.05$) with local lines B549, B137B, B138, B629, SCAM 151, and B342. The majority of genotypes were not significantly different from each other which is a strong indication that exotic lines are equally adapted and could be useful in improving cowpea yield in Botswana. Other drought adaptation phenotypic trait measured in this study were harvest index, grain filling index, drought intensity and SPAD meter measurement. Our results to date are presented.

Paper Number: 1331 (Poster Number: 203)

Response of Cowpea Genotypes to Water Stress Induced at Flowering Stage.

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Cowpea provides a cheap source of protein and vitamins for small scale farmers in Uganda. Moisture stress, however, remains a challenge in the drought prone areas of eastern and north eastern regions with yield losses of up to 50% been reported. Cultivars grown by farmers are not drought tolerant. This study was, therefore, undertaken to identify cowpea genotypes tolerant to drought. Thirty farmer preferred accessions were screened for drought tolerance at flowering stage. The experiment was laid in a split plot design, with a randomized complete block arrangement, evaluating 3 water regimes and 3 replications in a screen house at Makerere University Agricultural Research Institute Kabanyolo. The genotypes showed considerable variability in tolerance to drought. Genotypes, water regime and genotype \times water regime interactions were highly significant for yield, number of pods per plant, number of seeds per pod and hundred seed weight at $P < 0.001$. The water stress levels explained a greater proportion of the variation observed in grain yield, number of pods per plant, number of seeds per pod, 100 seed weight and days to flowering than genotypes and genotype \times water regime interaction. Yield reduction under intermediate water and severe water stress levels ranged from 5 to 100%. Genotypes such as Secow 2w, Secow 3B, Secow 4w, Secow 5T, MU15, MU24C, NE44, WC8, 182, IT84 and IT91 showed considerable levels of drought tolerance implying that they can be utilized in breeding for drought tolerant cowpea lines.

Paper Number: 1332 (Poster Number: 204)

Integration of Climbing Bean in the Smallholder Farming Systems in Malawi.

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The common bean (*Phaseolus vulgaris* L.) is grown in Malawi for both food, and cash income through sales in domestic and export markets. Most smallholder farmers grow either bush bean varieties in pure stand or under maize intercrop. The climbing bean varieties are often intercropped with maize or supported with stakes in pure stand. CIAT has developed highly productive medium altitude climbing bean varieties, which needed to be evaluated for suitability to give good returns on farmers' investments in Malawi. This study evaluated 19 medium altitude climbing bean varieties plus one control, under both monocrop and maize-bean cropping systems in replicated trials on-station and on-farm in order to assess the costs and benefits of the two cropping systems in different bean production agro-ecologies in Malawi. The study identified high yielding and disease (BCMV) resistant genotypes which responded differently in different agro-ecologies and cropping systems. Cool temperatures tended to favor intercropping. Results further showed that similar man-days were required to manage the bean crop either cropping system - monocrop or intercrop. However, on average farmers realized slightly more benefits from bean monocrop (MK 347,347 (\$631)) than from the intercrop (MK306, 476 (\$557)). The low benefits under intercrop were a result of reduced bean yield 385 kg/ha and the low price of maize, meant that the value of the maize could not off-set the lost bean value. It is thus recommended that there is still need for further research on how best the new improved climbing beans can be integrated in the current smallholder farming systems in Malawi.

Paper Number: 1333 (Poster Number: 205)

Evaluating Grain and Biomass Yield of Four Legume Species for Drought Tolerance in Eastern Kenya.

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Farmers in Eastern Kenya experience low farm production and incomes due to drought and declining soil fertility. Drought tolerant legumes can be used to mitigate the effects of drought as well as improving soil fertility through nitrogen fixation and as manure. The study was to evaluate four legume species under drought stress conditions in Eastern Kenya. This study was conducted in Makueni County during the 2014 long rain season in three locations. The mean number of days to 50 % flowering was 38, 56, 60 and 75 DAP in beans, cowpeas, Lablab accession CP1 81364 and Lablab variety KAT/DL-1 respectively. The biomass and grain yield of the four legume species were significantly different at $P \leq 0.05$. Biomass yield at flowering was highest in Lablab variety KAT/DL-1 (2770 kg/ha). Lablab accession CP1 81364, cowpeas and beans had biomass yields of 1927 kg/ha 1642 kg/ha and 1276 kg/ha respectively. The biomass yield at harvest was also highest in Lablab variety KAT/DL-1 (3545 kg/ha). Lablab accession CP1 81364, cowpeas and beans had biomass yields of 2694 kg/ha and 2371 kg/ha and 706 kg/ha respectively. Cowpeas had the highest grain yield (1569 kg/ha). Lablab variety KAT/DL-1, Lablab accession CP1 81364 and beans had grain yields of 1050 kg/ha, 659 kg/ha and 516 kg/ha respectively. The results of this study show that cowpeas and lablab variety KAT/DL-1 have better grain and biomass yield hence better adapted to drought stress in Eastern Kenya. Further research on their BNF potential in the area should be done.

Paper Number: 1334 (Poster Number: 206)

Integration of Climbing Beans in the Smallholder Farming Systems in Malawi.

Rowland Chirwa, International Center for Tropical Agriculture (CIAT) and Virginia Chisale, DARS*

Paper Number: 1335 (Poster Number: 207)

Drought Tolerant Bean Varieties Offer Hope to Smallholder Farmers in Malawi.

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The 2014/15 season was a nightmare in Malawi as the country faced floods at the beginning of the season and then terminal drought. Most farmers lost property and crops through flooding and water lodging while surviving crop fields were burnt dry prematurely by the terminal drought. The incidences of either terminal or intermittent drought are frequent in Southern Africa and reduce bean yield. In response to the need to develop drought tolerant beans, CIAT has been testing drought tolerant bush bean genotypes in Dedza and Ntcheu under Africa RISING project.

Eight different management options were implemented and these were sole beans unfertilised, sole bean with manure, maize with manure and NPS fertilizer, bean-maize intercrop with NPS fertilizer, bean-maize intercrop with both manure and NPS fertilizer, sole bean with both manure and NPS fertilizer, bean-maize intercrop unfertilized and bean-maize intercrop with manure. The two bean genotypes used in these trials were SER45 and SER83. During the season, Participatory Technology Evaluation (PTE) was conducted. As other crops suffered, the bush bean survived the ordeal and was described as the hope towards mitigating against the effects of climate change. While maize failed completely in plots which did not have either organic or inorganic inputs, beans produced pods and matured properly. Pod count showed big differences between SER 83 (124pods/plant) and the adjacent local variety (27pods/plant). The Department of Agricultural Research Services, through the bean breeding program, has since committed to present for release at least two drought tolerant bean varieties.

Paper Number: 1336 (Poster Number: 208)

Evaluation of Cowpea (*Vigna unguiculata* L. Walp.) Genotypes for Adaptation to Low P Soil Conditions.

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Cowpea is one of the most important legumes that provides food, fodder and cash to small scale farmers in Sub-Saharan Africa (SSA). It is also a source of soil fertility improvement as it replenishes soil nitrogen. Basic research has indicated that nitrogen (N) and phosphorus (P) are among the main edaphic factors that limit crop production in SSA. As a nitrogen fixing legume, cowpea production is not significantly affected by N deficiency in soils, hence P is the major mineral limiting its yield. Eighty (80) cowpea genotypes composed of both landraces and breeding lines were screened in the field for their reactions to low P soil conditions. The treatments consisted of low P (no P application) and high P (application of Simple Super Phosphate at 33 kg/ha). The collected data were subjected to cluster analysis which distributed the cowpea lines into four (4) groups. Group G4 is made up of 8 accessions with efficient P utilization as well as positive response to P application. G1 and G3 have the largest number of lines with 28 and 32 accessions respectively. The lines in these two groups have intermediate adaptation to low P soil conditions, however G1 accessions perform better in comparison to the ones in G3. G2 is composed mainly of 12 IITA breeding lines characterized by very poor performance in P deficient soils, and also respond poorly to P application. G4 lines could therefore, be used in breeding programs to develop cowpea varieties with good adaptation to small scale farmers' conditions of P deficient soils.

Paper Number: 1337 (Poster Number: 209)

Water Use Efficiency As a Tool for Drought Resistance Selection in Cowpea.

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With the potential impact of climate change and consequential drought, there is a need to identify and develop tools that can be used for plant selection under water deficit conditions. A field study was conducted with six cowpea genotypes from December 2014 to May 2015 at the Botswana College of Agriculture to determine the effect of soil moisture deficit on water use efficiency and its association with plant morphology and grain yield. Data was collected on plant morphological characteristics; days to flowering and maturity, plant canopy spread and plant height at maturity, grain yield (GY) and its components, plant water relation responses, RWC%, specific leaf area (SLA), plant survival under severe drought and water use efficiency (WUE). The ANOVA indicated that when subjected to water deficit, there were genotypic differences for days to flowering and maturity, plant height and canopy spread at maturity, grain yield and its components, leaf characteristics, relative water content (RWC%), survival under severe drought stress and WUE. Regression analysis showed that WUE was positively related to grain yield (GY) ($P < 0.0001$) and plant survival under severe drought stress ($P < 0.01$), but negatively related with water use (WU), (SLA), canopy spread and maturity at $P < 0.0001$. The strength of relationships was high under water deficit compared to the well-watered controls. The results further showed genotypic differences for WUE and associated responses. These findings demonstrate that WUE can be a selection tool in cowpea breeding programmes for drought stress resistance.

Key Words: grain yield, specific leaf area, canopy spread, water deficit.

Paper Number: 1338 (Poster Number: 210)

Screening of Cowpea (*Vigna unguiculata* [L] Walp.) Genotypes for Drought Tolerance.

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Drought is one of the major factors limiting crop yield. A trial was conducted to screen twenty cowpea (*Vigna unguiculata* [L] Walp.) genotypes for drought tolerance under translucent plastic house at Bunda College of Agriculture, University of Malawi. The trial was designed as split-plot with three soil moisture stresses levels (non, mild and severe stress) as main plot and twenty cowpea genotypes as sub-plot and replicated three times. Data on plant growth, yield components and grain yield of the 20 cowpea genotypes in response to soil moisture stresses were collected and analyzed using GenStat and SPSS computer packages. There were significant reduction in cowpea yield components and growth parameters in response to soil moisture stress. The correlation analysis revealed that yield component and growth parameters were positively correlated with grain yield. In terms of yield potentials, Drought Susceptibility Index (DSI) and Rank Summation Index (RSI) genotypes IT03K-337-6, IT03K-351-3, IT82E - 16 and BUNDA Accn 01 were the best, while Local variety, IT97K-825-3, IT99K-377-1, IT98K-503-1, IT04K-332-1, IT98K-476-8 and IT04K-321-2 were the most susceptible. Genotypes IT03K-351-3 and IT82E-16 were drought tolerant and high yielding and can be further evaluated for possible release. Genotypes IT99K-7-21-2-2, IT99K-494-6, and Bunda Acc-01 which are good Alectra vogelii resistant have also shown to be high yielding but are susceptible to drought. These lines can be crossed to drought tolerant genotypes to combine all three traits (drought tolerance, high yield and resistance to Alectra vogelii).

Key words: Cowpea, genotypes, drought tolerance, high yielding

Paper Number: 1339 (Poster Number: 211)

Diagnosing Common Bean Limiting Nutrient in Paddy-Rice Production System in Northern Mozambique.

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One of the most common food crop production system in Northern Zambézia Province, Mozambique is a paddy-rice during the rainy season and common bean (*Phaseolus vulgaris*, L.) during the drier part of the year. A factorial experiment of the following fertilizer applications was carried out near Mepuagiua village to identify the major and minor nutrient requirements. Eight treatments were compared: 1) control (no fertilizer added), 2) PK, 3) NK, 4) NP, 5) NPK, 6) NPKS, 7) NPKS + Zn and 8) NPKS + Zn and B. The experiment was carried out on two contrasting soil types, a probable Oxisol and a Luvisol. A composite soil sampling from surface and subsurface layers were conducted prior to establishment of field experiment for physical and chemical analyses. Samples were tested for pH, base saturation and CEC using standard procedure. The soils are moderately acidic and plant available P was below adequate levels (less < 21 mg g⁻¹). Agronomic parameters were collected for mean comparison among treatments. The mean yield ranged from 211. kg ha⁻¹ and 1064. kg ha⁻¹. The lowest yield was observed in treatment 1 (control) and the highest yield were observed were N, P and K where applied, which suggests that N, P and K are the most limiting plant nutrient in paddy-rice production area. The addition of micronutrients increased overall bean yield in more than 20% when compared with NP or PK treatment. Follow-up experiments on bean will follow in the upcoming dry season.

Paper Number: 1340 (Poster Number: 212)

Rhizosphere P Depletion and Levels of Acid and Alkaline Phosphatases Using Different Test Crops.

Flora Pule-Meulenberg, Phodiso Mooketsi and Bagadzi Brenda Mothusi, Botswana College of Agriculture*

Abiotic factors limiting crop production in Botswana include low soil moisture and low essential nutrients, especially N and P. In addition, soil pH is often low due to leaching of basic cations since soils are highly weathered with low concentration of nutrients. Despite the harsh environmental conditions and low inherent soil fertility that prevail, plant grow in those soils. Root induced changes of the rhizosphere have important consequences for plant nutrition. For example, elevated levels of acid and alkaline phosphatases have been found in roots and rhizosphere of cowpea plants. Studies were conducted at the Botswana College of Agriculture to compare the rhizosphere P depletion in cowpea (*Vigna unguiculata* L. Walp), Bambara groundnut (*Vigna subterranea* L. Verdc.) and maize (*Zea mays*) in pots using soils collected from three different locations in Botswana. For all the soils, cowpea exhibited the highest shoot N and P followed by Bambara groundnut and maize. For all the three crops, rhizosphere P was much higher than the bulk value. In another study, levels of acid and alkaline phosphatases were compared in rhizosphere and bulk soil where three genotypes of cowpea namely Black eye, Tswana and Rhinoster were grown.

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Results showed that the Tswana variety showed significantly highest rhizosphere acid phosphatase compared to Black eye. Results of this study are highly significant for smallholder farmers who cannot afford the cost of inorganic fertilisers. This study has shown that legumes are important in nutrient-poor environments due to their ability to scavenge for the much needed nutrients.

Paper Number: 1341 (Poster Number: 213)

Evaluation of Bean Germplasm Developed for Drought Tolerance in Malawi.

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Common bean is a legume of economic and nutritional importance not only for small scale farmers but also for the entire population of Malawi, but productivity is hampered by terminal or intermittent drought stress. As such, there is need to have acceptable bean varieties that can be productive under drought stress conditions. In this study, the twenty-four bean genotypes developed for drought resistance and two control varieties were evaluated in replicated trial under drought stress and non-stress conditions on station at Kasinthula, Bvumbwe and Kandiani for drought tolerance. The genotypes were also evaluated at Bvumbwe for response to phosphorus and N₂-fixation, then at Chitedze and Bembeke for disease resistance and response to soil fertility stresses. The promising germplasm were also evaluated on-farm at Bokosi and Chimseu in Kasungu where participatory variety selection (PVS) was done. Data from all these trials were analyzed using Genstat version 17. The study identified potential drought tolerant genotypes which included SER43, SER124, SER83 and SER75 that consistently performed much better ($P < 0.001$) than the check variety (CAL 143). One genotype, MR14215-9 was adapted to both drought and non-drought conditions, and was amongst the farmer preferred genotypes. Data from PVS showed that farmer selection criteria leaned towards preferred grain market classes, which were inconsistent with the superior yield performance of the genotypes under drought stress, suggesting the need to engage clients at an earlier stage in developing stress tolerant bean genotypes to capture clients' preferred traits.

Key words: Drought tolerance, stability, participatory variety selection, agro-ecologies

Paper Number: 1342 (Poster Number: 214)

Impact of Sowing Dates on Agronomic Performances of Cowpea (*Vigna unguiculata* (L.) Walp) Genotypes.

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Today, crops adaptation to a changing climate is one of the most important challenges for plant breeders. An experiment was conducted at Tarna research station in Maradi, in order to investigate the performance of thirty six (36) cowpea genotypes sown under three (3) different planting dates in 2012. Cowpea genotypes were arranged in a randomized complete block design (RCBD) with four replications. The results showed that sowing dates influenced significantly cowpea productivity. The mean grain yields of cowpea genotypes range from 1624 kg/ha to 1226 kg/ha from the first sowing date to the third one giving a grain yield loss of 25%. Genotypes x Sowing Date interaction analysis revealed highly significance for cowpea genotypes, sowing dates, and as well as parameters such as 50% flowering, 50% maturity, pod filling time and grain yield. Cowpea genotypes TN88-63, IN06I and IT97-573-1-1 with relatively shorter days before reaching maturity recorded the highest grain mean yield of 2087 kg/ha, 2086 kg/ha and 1856 kg/ha respectively. The highest fodder yield was recorded by HTR and TN256-87 with respectively 6898 kg/ha and 6759 kg/ha. Highly significant positive correlation ($r = 0.98^{**}$) was observed between grain yield and pod yield while a negative correlation ($r = -0.68^*$) was observed between fodder yield and harvest index. This study revealed that IT99-573-1-1 and TN88-63 which escaped the mid and late drought during the experiment were the best flexible cowpea genotypes with a relative adaption to sowing dates variations. Thus, these varieties can be recommended to farmers to be sown till mid-July during the raining season in the Sahel conditions. Key words: Cowpea, sowing dates, genotype x sowing dates, Sahel conditions.

Paper Number: 1343 (Poster Number: 215)

Cowpea Breeding Opportunities and Production Challenges for Climate Resilient in Ethiopia.

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Abstract Cowpea is an important grain legume grown and consumed in dryland areas of Ethiopia. Its ability to grow under diverse agro-climatic conditions in different cropping systems is associated with a wide range of biotic and abiotic production constraints. More than 50% of the Ethiopian arable land falls within dryland environments where rainfall is usually inadequate, poorly distributed, and varies with years and seasons.

Paper/Poster Abstracts

Therefore, Ethiopia is a center of diversity for cowpea and there is a great opportunities to improve cowpea for resistance to biotic and abiotic stresses and there is a need for selection of drought tolerant and short-season crop varieties that fit the growing season of such areas. Major cowpea production constraints in Ethiopia are scarcity of sufficient improved varieties for climate resilient such as drought, disease, weed and insect pest attacks at field, storage and in adequate cultural practices, low soil fertility and poor technology dissemination and popularization. However, only six cowpea varieties released from 1976 up to now with recommended production packages in Ethiopia in a one-size-fits-all fashion. Currently, Ethiopian government has given a good research attention for this crop due alleviating production and productivity of crop. It is therefore, important to revive research in this crop and to develop more varieties for biotic and abiotic stress resistance to wide range of Ethiopia. The current research focuses is to increase cowpea production, improve small holder household nutrition, improve the soils and possibly increase household incomes from the sales of the cowpea. Keywords/ Phrases: Abiotic stress, Biotic stress, Production constraints

Paper Number: 1344 (Poster Number: 216)

Increasing Efficiency in Cowpea-Cassava Crop Combinations in Kaoma, Zambia.

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Smallholder farmers in Zambia practice mixed crop farming. Cowpea (*Vigna unguiculata* (L) Walp) is an important legume as it supports food and income security for poor farm families. Cowpea is a prominent crop in cassava cropping systems which contributes significantly to the soil quality and the soil nitrogen budget. Often cowpea-cassava systems are under-fertilized due to resource limitations leading to low productivity and soil degradation. To evaluate options of increasing productivity in cowpea-cassava crop combinations, experiments were conducted in Kaoma on sandy loam soils. Yield data from crop combinations (main plot) and fertilizer rates (sub-plot) were analysed to determine suitable management practices for cowpea-cassava crop combinations. The most limiting nutrient was determined from modelling data using QUEFTS.

Paper Number: 1345 (Poster Number: 217)

“Pulse Panchayats” - an Innovative Concept in Enhancing Productivity and Profitability of Pulses in Semiarid Regions of India.

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In India Pulses cultivation is mostly (85% area) under rainfed conditions by poor farmers with non-availability of high yielding and location specific variety, low seed replacement rate, susceptibility to pests, diseases, inefficient storage and market linkages. Pulse producing states have recently witnessed weather related issues resulting in importing 3-5 Mt (for 2015 - about 10Mt) of Pulses annually to meet the domestic demand. To achieve self-sufficiency in pulses, domestic demand for 2030 is projected to be 32 Mt. Hence the productivity needs to be doubled and an additional area of about 3.0 M ha brought under pulses besides reducing post-harvest losses. M.S.Swaminathan Research Foundation is promoting the concept of “Pulse Panchayats” through enhancing Natural Resources Management in two Semi Arid States of India. Vulnerability assessment has enabled understanding of coping mechanisms by farmers to climate variability. Climate resilient Pulse varieties of Black gram, Green gram, Red gram and Moth bean to Abiotic and Biotic stress factors were identified from 90 trials. Through Integrated Crop Management practices enhanced the productivity by 30% and adaptive capacity by 70%. Knowledge management through Farmers Field Schools using ICT tools were integrated through Village Knowledge Centres reaching over 1 million populations. Pulse Bio Park established for strengthening the local seed production systems, innovative storage bags, value addition managed by Farmer Producer Companies as a business model. The “Pulse Panchayat” movement is envisaged to have significant importance in Grain Legume research and development especially in countries with low income and high rates of undernourishment.

Paper Number: 1346 (Poster Number: 218)

Assessment of Population Density of Indigenous Cowpea Rhizobia in Nigerian Soil Using the Plant Infection Technique.

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The ability of legumes to nodulate with indigenous rhizobia in soil is of paramount importance in determining whether the legume can benefit from inoculation. The size of the population of indigenous rhizobia in soil affects greatly the ability of cowpea to nodulate and fix nitrogen fixation.

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The indigenous rhizobia population and nodulation status of cowpea was assessed in a growth chamber using cowpea as a trap plant in soils collected from 30 different farm fields previously cultivated with cowpea from three different agro-ecological zones of Northern Nigeria. The most probable number of rhizobia in each soil among the sites, as estimated by the plant infection techniques varied from undetectable numbers to 1.7×10^4 cells g⁻¹ of soil. There were marked variations in the rhizobia population size among different agro-ecological zones, with the largest populations in soils from Kano and Niger. The rhizobia populations observed in the different sites are adequate to give satisfactory nodulation and nitrogen fixation in most cases. Further research will explore the possibility of increasing yields with elite rhizobium strains. Keywords: *Vigna unguiculata*, Rhizobia, Nodulation, most probable number, Northern Nigeria, Inoculant.

Paper Number: 1347 (Poster Number: 219)

Biological Nitrogen Fixation in Field Grown Groundnut As Quantified through ¹⁵N Natural Abundance Technique.

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Groundnut (*Arachis hypogaea* L.) is the most important grain legume in Ghana. However, poor soil fertility together with erratic rainfall distribution results in drastic yield reduction. Groundnut forms symbiotic relationship with rhizobia and fix atmospheric N₂ resulting in high crop productivity. Increasing food demand and the need to reduce carbon emissions makes this relationship a critical alternative to chemical N fertilizer use. Therefore the need to identify genotypes with superior symbiotic ability cannot be overemphasised. Previous studies on symbiotic efficiency of groundnut in Ghana have considered few genotypes. This study therefore evaluated the symbiotic efficiency, plant growth and pod yield of 21 groundnut genotypes in the Guinea savanna of Ghana in randomised complete blocks with four replicates. Symbiotic N contribution was assessed using the ¹⁵N natural abundance technique. There was significant variation in symbiotic efficiency, plant growth and pod yield among genotypes. Average N contribution by groundnut genotypes ranged from 48 to 108 kg N ha⁻¹ while mean pod yield ranged from 0.58 to 2.1 t ha⁻¹. Genotypes ICGV-IS 08837, ICG 6222 and NKATIESARI demonstrated superior symbiotic performance, plant growth and pod yield. ICGV-IS 08837 yielded 2.5 fold more than CHINESE which is the most widely cultivated variety in the region. In conclusion, genotypes ICGV-IS 08837, ICG 6222 and ICGV 03315 are recommended for further evaluations. To the best of our knowledge this is the first study to use ¹⁵N natural abundance technique to quantify N₂ fixation in Ghana.

Paper Number: 1348 (Poster Number: 220)

Assessment of Sustainable Production of Pigeon Peas in SMALL Scale Farmsers in Morogoro Region - Tanzania.

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Abstract

High percentage of people from eastern and southern Africa live below the poverty line. Therefore ability of them to get access to basic needs became limited even in situations where they have access to land, they are unable to afford sufficient fertilizers and other farm inputs to produce sufficient crop. However growing legume crops i.e. Pigeon pea, beans, cowpeas and cereals i.e. maize and sorghum in one farm provide an opportunity to reduce expenses of using industrial fertilizers hence presents a great potential for improving livelihoods for resource poor African farmers. This brief highlights the potential contribution of legume crops to food security, income, the best management practices and policy implications for improving production. Beside good price of pigeon peas in 2015 in Tanzania many farmers still did not benefit from affordable price ever recorded, the constraints behind were believed to use of local varieties resulting in low yield, high cost of labour, inadequate processing and storage facilities, weed/pest infestation and lack of credit/ loans from banks and other financial institutions. It is believed that in order to enhance pigeon peas productivity then extension service should be made available to farmers, improved varieties should be available under subsidy price to farmers, marketing policy to govern pigeon peas sales. And joint venture between all pigeon peas stake holders.

Paper Number: 1349 (Poster Number: 221)

Symbiotic Potential of Isolates from Indigenous Rhizobia Population in Ghana.

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SYMBIOTIC POTENTIAL OF ISOLATES FROM INDIGENOUS RHIZOBIA POPULATION IN GHANA O. Osei^{1*}, R. C. Abaidoo^{2,3}, N. Ewusi-Mensah¹, J. Ulzen¹ and A. Opoku¹. Department of Crop and Soil Sciences, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

2. Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana 3. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria Abstract Wild legumes are said to harbor diverse promiscuous rhizobia which are competitive and effective and thus play important role in soil fertility replenishment through biological nitrogen fixation. However, few studies in Ghana have attempted to recover isolates from these indigenous wild - legume rhizobia population. To obtain indigenous rhizobia strains that are superior and competitive than existing exotic industrial strains for inoculant production, rhizobia strains were isolated from nodules of some wild legumes. Symbiotic effectiveness of 13 % infective isolates were estimated by comparing their shoot dry weights to that of commercial strains; 532 C and expressed as a percentage. Based on the estimation three effectiveness classes were established; highly effective (9 %), effective (36 %) and lowly effective (55 %) respectively. Rhizobia inoculation caused significant variation ($P < 0.05$) in the shoot dry weights of soybean with isolates NAG 168 and 211 performing similar ($P > 0.05$) to the commercial strain (532 C) in potted non - sterile soil under greenhouse conditions. These results indicate the possibility of obtaining highly effective wild - legume rhizobia that can effectively nodulate soybean for local inoculant production.

Paper Number: 1350 (Poster Number: 222)

Optimising Biological Nitrogen Fixation in Common Beans Along an Agro-Ecological Gradient in West-Nile Farming Systems of Uganda.

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Abstract

Common bean (*Phaseolus vulgaris* L.) is the most important grain legume in Uganda which forms a large constituent of the diets of the majority of the population. Despite increase in the area under beans, on-farm yields average 0.3 Mg ha⁻¹ compared with 3.0 Mg ha⁻¹ reported in research stations. Low soil phosphorus and nitrogen and weather variability are major contributors to low yields.

To offset the high costs of fertilizers, emphasis has been placed on optimization of the use of naturally available sources of nutrients, especially biological nitrogen fixation (BNF). However, there is limited information about the amount of N fixed by legumes, how this is influenced by soil fertility gradient across contrasting agro-ecological zones (AEZs) and if the amount fixed can offset the plant demand for nitrogen. A reconnaissance survey was conducted in three AEZs: low-altitude, mid-altitude and high-altitude in the West- Nile Farming system, northern Uganda where farmers' fields were characterised as of poor, moderate and high fertility, giving a total of 36 farmers.

Preliminary results show high variability in farms under bean production. The fields have been characterised and soil samples collected for analysis. Trials have been established to evaluate responses of beans to phosphorus application at three levels (0, 15, 30 kg P ha⁻¹) with or without inoculation with Rhizobia for monoculture and maize-bean intercrop under each field category. Data collection to quantify BNF and yield parameters of beans and maize is on-going and the results of the experiments will be shared in this conference.

Paper Number: 1351 (Poster Number: 223)

Symbiotically Effective Native Rhizobial Obviate Significant Response to Inoculation with Foreign Strains.

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Rhizobium inoculation is an option for increasing grain yield of legumes in nitrogen deficient soils; however, low effective and competitive indigenous rhizobia obviate its significant response. The performance of a commercial strain (532 C) and indigenous rhizobia was evaluated on biological nitrogen fixation and grain yields of soybean and cowpea in a field and greenhouse experiment. The application of 532 C strain produced grain yield (1,908 kg ha⁻¹) which was significantly lower than the uninoculated nitrogen - fertilized plants (2,150 kg ha⁻¹) and the uninoculated control without nitrogen (2029 kg ha⁻¹). The amount of N supplied through biological nitrogen fixation in both soybean and cowpea was not significantly affected by inoculation with 532 C. However, 532 C led to higher N fixation in soybean (117.7 kg N ha⁻¹) than in cowpea (26.9 kg N ha⁻¹). Soybean and cowpea did not respond to the introduced inoculum strains 532 C in terms of grain yield and biological nitrogen fixation due to highly effective native rhizobia which were likely to be more competitive than the introduced strain 532 C. The results show that the indigenous rhizobia can support soybean production.

Paper Number: 1352 (Poster Number: 224)

The Effect of Planting Date on N₂ Fixation and C Accumulation of 30 Cowpea Genotypes Planted at Two Locations in Mozambique.

Abudo Rachad Ussene Sr., International Institute of Tropical Agriculture, Mozambique*

The grains of cowpea (*Vigna unguiculata*) contains 25% protein and 64% carbohydrates (Bressani, 1985), and can potentially alleviate malnutrition among children of resource-poor African households. Additionally, it contributes huge amount of symbiotically fixed-N (up to 201 kg N ha⁻¹) to improve soil fertility and sustains system productivity (Dakora, 2010). The growth, N₂ fixation, and grain yield of cowpea is largely affected by changes in rainfall pattern, and the lack of information on optimum planting dates. To alleviate these constraints, decisions on appropriate planting date need greater attention. The symbiotic N contribution in 30 cowpea genotypes planted at two different planting dates (15th January and 30th February, 2011) were assessed under field conditions in Mozambique, using the 15N natural abundance technique. C assimilation was assessed analyzing shoot samples for 13C/12C isotopes. The results showed marked variations among the genotypes in terms of the amounts of N-fixed and C accumulation. The genotypes IT97K-1069-6, IT98K-128-3, IT97K-390-2, IT98K-412-3, IT03K-324-9, IT04K-221-1, IT99K-494-6, IT04K-227-4 recorded higher amounts of N-fixed at all three locations. Grain yield was higher in the genotypes IT04K-321-2, IT04K-227-4, IT00K-126-3, IT-18 and IT97K-390-2 at Muriaze. Genotypes sown in the second week of January produced greater grain yield than those planted in the last week of February. The findings of this study could be used to improve the cultivation of cowpea in Mozambique and other areas with similar soil and climate.

Paper Number: 1353 (Poster Number: 225)

Characterization of Twenty-One Common Bean Genotypes for Biological Nitrogen Fixation Under Drought Stress.

Crocus Zinha Hamsini, LUANAR*

Research Abstract

Nitrogen fixation in common beans is usually low yet the nutrient derived through this process, Nitrogen, is a major element required in large quantities. The nitrogen fixation of twenty-one common beans genotypes was assessed under drought and well-watered conditions and inoculated and non-inoculated conditions. Total nitrogen in plant tissue and soil was analyzed and the results were used for calculating nitrogen fixation using the nitrogen difference method. Maize was used as the control or reference crop. A uniform dose of fertilizer (23:21:0 4S) was also applied to all plots to boost shoot growth. The twenty-one genotypes had four different growth habits. There were six type IIIa; five type IIIb; five type IVa; and five type IVb. As for type IIIa genotypes, total plant nitrogen was significant for water regime*genotype at flowering (<.001) and at mid-pod fill (0.001) with BCB2 having the highest nitrogen content under drought (mid-pod fill) followed by VTTT925/9-1-2 then DRK 57. Type IIIb, had total plant nitrogen significant for water regime*genotype at <.001 both at flowering and at mid-pod fill with AFR703 highest followed by A344 under drought. The genotypes that performed better under drought for total plant nitrogen in type IVa were CIM-Climb01-03-04, MAC 109 and 12D/2. The genotypes that performed better under drought for total plant nitrogen in type IVb were CIM-Climb01-03-34, CIM-RWV1040-5-1-2 and MBC41. The total number of seeds for type IIIa were highest from BCB2, followed by DRK 57 and then Sugar 131 variety. There were also significant values for number of nodules for genotypes and inoculation (P <. 001 and P 0.011). All growth habits exhibited differential contributions of yield, nodule number, nodule color, and %Nitrogen. The results show that there are potential nitrogen fixers under drought stress in each growth habit which may be used for selection for drought tolerance.

Paper Number: 1354 (Poster Number: 226)

The Influence of Rhizobia Inoculation and Phosphorus Fertilizer on Yield and Quality of Cowpea Fodder in Northern Ghana.

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The influence of rhizobia inoculation and phosphorus fertilizer on yield and quality of cowpea fodder in northern Ghana
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ABSTRACT

Cowpea (*Vigna unguiculata* L. Walp.) is one of the key legumes for smallholder farmers in West Africa. Cowpea production is a major source food, feed and income for many smallholders and their animals. Cowpea haulm is noted to increase microbial nitrogen supply in ruminants when used as supplement to other low quality feed. However, the grain and fodder yield of cowpea is currently low in Ghana.

A study was conducted investigated the effects of inoculation and phosphorus fertilizer on the yield and fodder quality of three improved cultivars of cowpea. Split-plot design was used with a replicate in four different communities in Savelugu-Nanton district of Ghana. The treatments were: songotra, padituya and apagbaala varieties as main plot factor and combinations of inoculation and phosphorus fertilizer as sub-plot factors (inoculant only, phosphorus only, phosphorus and inoculant and control) The inoculant used is called BR3262 from EMBRAPA. Results indicated that rhizobia inoculation and phosphorus fertilizer increased yield significantly ($p < 0.05$) of both grain and fodder as compared with control treatments between and among varieties. Padituya produced the most biomass yield (6.04 t/ha) while songotra produced the least (3.09.t/ha). Grain yields were not significantly different. There were no significant differences in number of nodules per plant. Fodder quality factors such as crude protein (CP), neutral detergent fibre (NDF), Acid detergent fibre (ADF) and in-vitro digestibility are being conducted to determine the treatment effects on the quality of cowpea haulms as fodder for livestock.

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Paper Number: 1355 (Poster Number: 227)

The Abundance of Indigenous Rhizobia Nodulating Common Bean in Uganda and the Soil Factors That Influence Them.

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Common bean is an important grain legumes in Uganda. It forms an important part of the traditional diet and provides income for the rural communities. Common bean is able to fix nitrogen through bacterial symbiosis and yields could potentially be increased through the use of rhizobial inoculants. Inoculant response depends on the abundance, competitiveness and effectiveness in N fixation of the indigenous compatible rhizobia in relation to the attributes of the inoculant strains. We therefore aim to determine the most-probable numbers (MPN) of indigenous rhizobia and the soil characteristics that influence them. Soils were sampled from the Montane and Mt Elgon Agro-ecological zones (AEZ) in Uganda. Indigenous rhizobia populations were determined using the plant infection technique and soils were subjected to physicochemical analysis. Among 29 soil samples assessed, the highest MPN was found in the bean-banana/coffee intercrop and the lowest in grasslands under sterile conditions using growth pouches supplied with sterile water and N-free nutrient solution. This data showed that the land use management system and cropping history determine the abundance of indigenous rhizobia but this is influenced by soil characteristics such as pH, organic matter and phosphorus content. Notably the organic matter ranged from 1.3-5.0%, pH 3.7-6.6, phosphorus content 2-69 ppm mg/kg and N content from 0.1-0.3%. Our next steps will be to isolate, characterise and test potential strains as inoculants that can be used to enhance common bean yields.

Key words: nitrogen fixation, MPN, physicochemical analysis

Paper Number: 1356 (Poster Number: 228)

Policing the Gate: Can Pea Plants Stop Rhizobial Cheats from Entering?.

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Legumes form symbioses with nitrogen-fixing soil bacteria called rhizobia. An intricate signalling process allows rhizobia to infect plant roots and form nodules. Inside nodules, rhizobia fix atmospheric nitrogen into ammonia and provide it to the plant. Rhizobial strains vary widely in how much nitrogen they provide and this influences crop yields. Despite some evidence to the contrary, there have been recent claims that legumes exert 'partner choice' and selectively form symbioses with rhizobia that provide more nitrogen. We tested whether peas exert such partner choice. As many traits influence the ability of rhizobia to form nodules, the only unbiased test of partner choice requires the use of strains that differ in their ability to fix nitrogen, but nothing else. We developed sets of wild-type nitrogen-fixing strains and their respective nifH mutant non-fixing strains. Strains were distinguished using chromosomal gusA and celB marker genes and were otherwise completely isogenic. Peas were inoculated with different ratios of wild type to mutant strains. We found that the percentage of nodules containing the wild type strain exactly reflected the percentage of the wild type strain in the inoculum. We therefore found no evidence for partner choice. Our results demonstrate that pea plants cannot exercise partner choice. This emphasizes the essential role of plant sanctions for plant and rhizobial fitness. In sanctioning, plants allocate fewer resources to established nodules providing little nitrogen. Ongoing work will focus on how such sanctions affect crop yields and populations of effective and less effective rhizobia in the soil.

Paper Number: 1357 (Poster Number: 229)

Response of Groundnut Genotypes to Rhizobia Inoculation in the Sudan Savanna of Nigeria.

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Paper Number: 1358 (Poster Number: 230)

The Effect of Planting Date on N₂ Fixation and C Accumulation of 30 Cowpea Genotypes Planted at Two Locations in Mozambique.

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The effect of planting date on N₂ fixation and C accumulation of 30 Cowpea genotypes planted at two locations in Mozambique. The grains of cowpea (*Vigna unguiculata*) contains 25% protein and 64% carbohydrates (Bressani, 1985), and can potentially alleviate malnutrition among children of resource-poor African households. Additionally, it contributes huge amount of symbiotically fixed-N (up to 201 kg N ha⁻¹) to improve soil fertility and sustains system productivity (Dakora, 2010). The growth, N₂ fixation, and grain yield of cowpea is largely affected by changes in rainfall pattern, and the lack of information on optimum planting dates. To alleviate these constraints, decisions on appropriate planting date need greater attention. The symbiotic N contribution in 30 cowpea genotypes planted at two different planting dates (15th and 30th January, 2011) were assessed under field conditions at two locations in Mozambique, using the ¹⁵N natural abundance technique. C assimilation was assessed by analyzing shoot samples for ¹³C/¹²C isotopes. The results showed marked variations among the genotypes in terms of the amounts of N-fixed and C accumulation. The genotypes IT-1069-6, IT04K-221-1, IT04K-227-4 recorded higher amounts of N-fixed at all two locations. Grain yield was higher in the genotypes IT07K-187-24, IT04K-227-4 and IT-126-3 ranging from 1001 to 3026 kg/ha when averaged across the two locations, Namialo and Muriaze. Genotypes sown in the 15th of January produced greater grain yield than those planted in the 30th of January. The results of this study could contribute to improve cowpea production in Mozambique and other areas with similar agro-ecology.

Paper Number: 1359 (Poster Number: 231)

Effects of Rhizobium, Azospirillum, and Rhizobium Azospirillumcoinoculation Inoculants on Climbing Beans Growth and Development in Low and High Phosphorus Sand Media.

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Growth and Development of Climbing bean varieties inoculated with Rhizobium and Azospirillum in low and high phosphorus sand media

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Abstract

Bean productivity in the highlands of Kenya is declining due to low soil nitrogen and phosphorus, poor symbiotic nitrogen fixation, limited use of fertilizers and organic amendments. Co-inoculation with Azospirillum and Rhizobium has the potential to enhance nitrogen fixation of bean genotypes in nitrogen and phosphorus limited conditions. The objective of the study was to determine the effect of Azospirillum, Rhizobia, control and coinoculation inoculants on nodulation and biomass yield of two climbing bean varieties under high and low phosphorus levels in greenhouse conditions on acid washed sand. The treatments were laid out in a split-split plot design replicated three times. P levels (0, 40 kg P ha⁻¹) were the main plots, inoculants, the sub-plots, and varieties the sub-sub plots. The collected data was analyzed using Genstat software (v12). Results showed that P application improved nodulation from 138 nodules per plant in low P sand to 291 nodules per plant in high P medium and biomass production was increased by 65%. Inoculation with Azospirillum increased biomass yield in high P sand by 27% compared to 65% in low P sand medium and inoculation with Rhizobium increased the biomass yield of beans by 138% in high P sand medium compared to 56% increase in low P medium. Co-inoculation (Azospirillum+Rhizobium) increased the biomass yield of climbing beans by 151% in high P sand compared with 107% in low P sand. Higher yield increases due to Azospirillum inoculation were realized in low P sand. Rhizobium inoculation resulted higher increase in biomass production in high P sand. Co-inoculation with Rhizobium and Azospirillum improved biomass yields of beans in high and low P sand media. Coinoculation has the potential to improve bean biomass production at low cost and is environment friendly.

Key words: Rhizobium, Azospirillum, climbing bean, nodulation, biomass yield

Paper Number: 1360 (Poster Number: 232)

Selecting Effective Indigenous Soybean-Nodulating Rhizobial Isolates from Ethiopia UNDER Glasshouse Conditions.

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The findings that proof the existence of soybean nodulating rhizobia in Ethiopia are a recent phenomenon and the symbiotic potential of these indigenous strains is still unexploited. Thus, the aim of this study was to assess the symbiotic efficiency of indigenous rhizobial isolates on two soybean genotypes namely Gishama and TGx-3326-44, in Ethiopia. Exotic rhizobial strains were also included. Glasshouse experiment was done on potted soils collected from Dorebafano and Zeway, southern and central Ethiopia respectively, with no history of rhizobial inoculation. There was a highly significant difference for nodulation, growth, % Ndfa and N-fixed of soybean plants between and among rhizobial isolates. Similar to that of rhizobial isolates variation; genotype variation for these parameters was very prominent. Genotype Gishama had greater shoot %N, N content, and N₂ fixation rates when inoculated with more than half of the Bradyrhizobium strains compared to genotype TGx-3326-44. The %Ndfa ranged from 33 to 70% for plants inoculated with TUTSDGI-52 and TUTSMCF-71, respectively. It is interesting that the indigenous rhizobial isolates had a comparable effectiveness in %Ndfa and amount of N₂-fixed compared with the exotic rhizobial strain such as USDA 110. The interaction effect of rhizobial isolates x host genotype x soil conditions seen in this study could show that the successful implementation of a legume-based cropping system and the efficiency of BNF depend on several biotic and abiotic factors. In conclusion, though further field experiments under variable environmental conditions are required, the results of this study indicated that there is an opportunity to efficiently utilize soybean and its microsymbionts for sustainable N supply in Ethiopian soils.

Paper Number: 1361 (Poster Number: 233)

Efficacy Assessment of Commercial Rhizobia Inoculants on Common Bean and Soybean Varieties Growth Performance in Two Soil Types.

*HEZEKIAH KORIR**, Egerton University

The use of inoculants offers an alternative to the use of chemical fertilizers and the quality and efficacy of these inoculant is critical to realize the benefit of inoculation. This study tested the quality of inoculant found in the market and evaluated the response of soybean and common bean to legume inoculants. Seeds were inoculated at the recommended rate at planting. Plants were grown under greenhouse conditions in a Completely Randomized Design. At mid podding, nodule number and weight, above ground biomass and root dry biomass and biologically fixed nitrogen were determined. The laboratory results showed variable quality of the inoculants in terms of the number of viable cell count and the number of microorganisms in the product. Nodule number and fresh weight per plant were higher with inoculant application for soybean and common bean relative to the controls. Biological nitrogen fixation was significantly improved as a results of inoculation. There was no significant benefit in inoculating seeds of the two legumes with the inoculants on above ground biomass and root biomass. Additionally, the soil type and the variety had an effect on the response to inoculation. There was no significant benefit in inoculating seeds of the two legumes with the inoculants on above ground biomass and root biomass. In general, the results suggest that to obtain the full benefits of biological nitrogen fixation, farmers need to be provided with the correct inoculant that are of good quality. Further work under field conditions is recommended to confirm these findings.

Paper Number: 1362 (Poster Number: 234)

CO-Inoculation of Rhizobia Strains and Native Phosphate Solubilizing Bacteria in Enhancing Common Bean Growth in a Low Phosphorus Soil.

*HEZEKIAH KORIR**, Egerton University

Nitrogen (N) fixation by legume-Rhizobium symbiosis is important to agricultural productivity and is therefore of great economic interest. Growing evidence indicates that soil phosphate solubilizing bacteria can positively affect symbiotic performance of rhizobia. The effect of co-inoculation with plant phosphate solubilizing bacteria (PSB) and rhizobium, on nodulation and growth of common bean (*Phaseolus vulgaris* L.) were investigated using a low phosphorous soil under greenhouse conditions. The PSB strains were isolated from common bean nodules from Nakuru County in central Rift valley in Kenya. The PSB strains were molecularly characterized by 16S rDNA partial gene sequencing. The PSB strains *Paenibacillus polymyxa* and *Bacillus megaterium* as well as two rhizobia strains and one reference rhizobia strain (CIAT 899) were used in this study. Common bean seeds of two varieties were inoculated with Rhizobium strains singly or in a combination with PSB to evaluate their effect on nodulation and growth parameters. A significant variation of plant growth in response to inoculation with Rhizobium strains was observed. Further, coinoculation of the rhizobia with PSB significantly increased nodule number and weight, shoot dry weight and root dry weight. Co-inoculation with Rhizobium and PSB demonstrated a significant increase in the proportion of growth of common bean.

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These results indicate that PSB strains have potential to enhance the symbiotic potential of rhizobia. Furthermore, these PGPR should be tested under field conditions to evaluate their effectiveness on the growth and ultimate yield of common bean.

Paper Number: 1363 (Poster Number: 235)

Legume Biological Nitrogen Fixation (BNF) Potential Contribution to Sustainable Smallholder CROP Production in Southern Africa.

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Nitrogen is the major limiting nutrient for crop production among resource-constrained smallholder farmers in sub-Saharan Africa. The symbiosis between legumes and nitrogen-fixing nodule bacteria (rhizobia) has potential to sustain crop production through N and organic matter inputs but is poorly characterized in African soils. Our research looked at the prevalence, population levels, N-fixing capacity and diversity of rhizobia nodulating a range of legume crops and their impact on N availability and crop yields in smallholder cropping environments in Zimbabwe. Our results showed that rhizobia nodulating African legumes cowpea (*Vigna unguiculata*), groundnuts (*Arachis hypogaea*) and bambarra nuts (*Vigna subteranea*) occur widely and effectively nodulate the host legumes, with cowpea nodule isolates showing diversity in symbiotic specificity among both fast- and slow-growing types. *Phaseolus vulgaris* nodulated poorly and often ineffectively in field soils. Soyabean nodulated poorly at most sites but some of the isolates were highly effective on commercial soyabean varieties. Promiscuous soyabean varieties such as Magoye, developed in Zambia and TGX lines from IITA, Nigeria, nodulated effectively with indigenous rhizobia in a wide range of soils, yielding up to 2.8 per ha grain and 5 - 10 tons per ha stover, demonstrating potential to impact on both food security and soil fertility replenishment. Amounts of N fixed ranged from 20 -74 kg N/ha. Our results demonstrate the high potential of legume BNF to sustain smallholder cropping in Africa through N and organic residues.

Paper Number: 1364 (Poster Number: 236)

Commercial Rhizobia Inoculants Effect on Grain Yield of Soybean and Cowpea in Ghana.

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Lowly effective and highly competitive indigenous rhizobia largely limit the grain yield of legumes in smallholder farms in Ghana. To address this limitation, a field experiment in a randomized completely block design was conducted to evaluate the performance of several commercial rhizobial inoculants on soybean and cowpea with the objective of obtaining highly effective strains for soybean and cowpea production in Northern Ghana. Commercial rhizobia inoculant significantly affected the grain yield of both soybean and cowpea. Yield increases ranges from 12 - 21 % for soybean and 24 - 38 % for cowpea. Orthogonal contrast analysis revealed that the performance of the commercial inoculant was superior to the indigenous rhizobia and also differ in their degree of effectiveness on cowpea. Commercial inoculant significantly affected nodulation and dry matter yield in both soybean and cowpea. The study identifies some commercial rhizobia inoculants which are highly effective and can be used to reduce yield gaps in smallholder farms in Northern Ghana.

Paper Number: 1365 (Poster Number: 237)

Effect of Inoculation with *Bradyrhizobium Japonicum* and Phosphorus Supply on Soybean Production in Two Types of Soil in Benin.

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Abstract The effect of *Bradyrhizobium japonicum* inoculation and phosphorus application on Soybean (*Glycine max* (L.) Merr.) production was studied by establishing two years experimentations in Benin. On station trial carried out at Sekou in 2007 and on farm experiments at Zado Dovogon (southern Benin) on "terre de barre" soil and at Yawa (centre of Benin) in 2008 on ferruginous soil. Four rates of P (0, 50, 100 and 150 kg ha⁻¹ of P₂O₅) were used on station and two rates of P on farmers fields (0 and 100 kg ha⁻¹ of P₂O₅) followed by inoculation treatments. Four replications were done on station while six farmers' fields representing six replications at Zado dovogon and Yawa. The results revealed that inoculation with *Bradyrhizobium japonicum* indicated significant improvement on growth, nodule number, shoot and grain yield of soybean but less than combination of application of *Bradyrhizobium japonicum* inoculation and phosphorus supply. For example, in station, peasant practice without fertilizer gave 249 kg ha⁻¹ of grain while inoculation gave 782 kg ha⁻¹. Inoculation combined to P₂O₅ application gave 1961 kg ha⁻¹ of grain. The supply of 150 kg ha⁻¹ of P₂O₅ combined to the inoculation significantly decreased growth, nodule number and yield of soybean. The most efficient combination of inoculation and phosphorus was 100 kg of P₂O₅ ha⁻¹.

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In addition, the results also showed low root colonization by mycorrhizae in the presence of high rates of P₂O₅. Similar trends were observed in farm experiment where inoculation combined to P₂O₅ application gave 1772 kg ha⁻¹ of grain at Zado Dovogon and 2285 kg ha⁻¹ of grain at Yawa. This study revealed that inoculation and the provision of P₂O₅ provide significant benefits to the plant and can be used to improve the growth and yield of soybean in different agro-ecological areas of Benin. Key Words: Soybean, Bradyrhizobium japonicum, Phosphorus, Mycorrhizae, Benin.

Paper Number: 1366 (Poster Number: 238)

Differential Potential of Cowpea Genotypes and Their Diversity for Resistance to Some Pest and Diseases.

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In sub-Saharan Africa, production of cowpea (*Vigna unguiculata* (L.) Walp) is structured by interaction with pests and diseases. Prior understanding of variation within the species for this biotic component is inevitable for classical breeding to obtain resistant genotypes. The present study assessed the vulnerability of twenty cowpea genotypes to two pests and two diseases. Variation in response of the 20 cowpea genotypes to Leaf eater (*Ootheca muthabilis* Salhib), Leafhoppers (*Empoasca* sp), leaf spot and powdery mildew were significant ($P \leq 0.01$). Similarity (as measured by Gower genetic distance) among the 20 genotypes ranged between 0.293 and 0.941, with a mean of 0.720. The proportion of the total variation due to principal components (PC) 1 and 2 was 71%. Leaf eater and powdery mildew had ≥ 0.45 Eigenvector loading in PC1 and PC2. The significant contribution of leafhopper to the total variation was rated 0.66 in PC2. At 0.1 point of similarity, five clusters subsisted. Cluster III had the highest population of ten member genotypes. IT89KD-374-57 x Nsukka-1 uniquely stood out in cluster IV. Response to Leaf spot and Leafhopper attack respectively differentiated the genotypes in cluster I and II. However, the 10 genotypes in cluster III had a uniform response to Leaf eater attack. A platform for group or individual genotype selection that can enhance breeding for resistance was evolved in this study.

Paper Number: 1367 (Poster Number: 239)

Identification of Common Bacterial Blight Resistant Sources for the Bean Breeding Program in Uganda.

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Common Bacterial Blight (CBB) caused by *Xanthomonas Campestris* pv. *Phaseoli* (Xcp) and *Xanthomonas* spp var. *fuscans* (Xcpf) is by far the most severe and widely occurring bacterial diseases of common bean in Uganda where it causes yield losses of up to 61.7%. Being seed-borne, it reduces seed quality through staining and browning and as such constitutes a real challenge for seed and yield production. The disease is more prevalent and severe in the low altitude areas of Uganda where major bean production occurs. Although various sources of resistance have been developed around the world, none of the varieties grown in Uganda is resistant. This study is aimed at identifying resistant germplasm among 132 accessions and contributes to the development of resistance within the preferred Ugandan market class Andean bean varieties. Results indicated highly significant differences (P

Paper Number: 1368 (Poster Number: 240)

Genetic Diversity and Population Structure of Ethiopian Common Bean (*Phaseolus vulgaris* L.) Germplasm.

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Abstract The strong division of the domesticated common bean gene pool in Andean and Mesoamerican groups presents clear challenges and opportunities for the use of common bean germplasm. The integrated use of phenotypic and molecular marker evaluation data helps categorize the identity of cluster groups identified at the molecular level. Hence, this study aimed at integrating morphological and agronomic evaluations with prior molecular diversity data from a collection of Ethiopian common bean germplasm. A Principal Coordinate Analysis, done with the accessions identified at the STRUCTURE preset K=2 of the marker analysis, revealed that accessions separated into the Mesoamerican and Andean gene pools along the first Principal Component axis, with a considerable number having intermediate phenotypic features between the Andean and Mesoamerican genotypes.

Furthermore, stepwise discriminant and canonical correlation analyses, using the non-hybrid accessions at STRUCTURE preset K=5, showed that there was separation among the Andean and Mesoamerican cluster groups, with some overlaps. Consequently, comparison of data on distinguishing agro-morphological traits showed that the three Andean cluster groups corresponded to the Andean races 'Nueva Granada' and 'Peru', whereas the two Mesoamerican groups were predominated by the Mesoamerican race 'Mesoamerica'. Among the important implications of the present results for future common bean breeding in Ethiopia, the reported presence of the Andean race 'Peru' is the first for common bean germplasm out of the Americas. Overall, the study showed that common bean germplasm of Ethiopia has a rich genetic diversity, which should be one of the top priorities of future common bean breeding programs.

Paper Number: 1369 (Poster Number: 241)

Breeding Black Beans for Haiti with Multiple Virus Resistance.

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Black bean production in the lowlands of Central America and the Caribbean is threatened by Bean golden yellow mosaic virus (BGYMV) and Bean common mosaic necrosis virus (BCMNV). Therefore, the objective of this research was to develop, test and release tropically-adapted black bean lines with resistance to these viral diseases. Black bean breeding lines from Zamorano, the University of Puerto Rico and CIAT were tested in field trials in Haiti by bean researchers of the National Seed Service (NSS) of the Ministry of Agriculture. 'DPC-40' was the first BGYMV and BCMNV resistant black bean to be released and disseminated in Haiti. This cultivar was originally developed and released in the Dominican Republic with support from the Dry Grain Pulse CRSP. A USAID funded Bean Technology Dissemination project supported the production and distribution of DPC-40 to small-scale farmers in Haiti. Another BGYMV and BCMNV resistant black bean, 'XRAV-40-4', was identified by NSS researchers to have earlier maturity than DPC-40. The performance of XRAV-40-4, released as 'Sankara', was validated in on-farm trials with support from FAO and in collaboration with NGO's. The BGYMV and BCMNV resistant black bean line MEN 2201-64 ML was identified by the NSS bean research program to combine earlier maturity and better adaptation to drought. The NSS bean research program continues to evaluate the performance of black bean breeding lines in field trials and on-farm trials. Long-term objectives are to identify black bean lines that combine multiple virus resistance with resistance to rust and greater tolerance to abiotic stresses such as drought and low soil fertility.

Paper Number: 1370 (Poster Number: 242)

Extent and Pattern of Genetic Diversity in Ethiopian White Lupin Landraces for Agronomical and Phenological Traits.

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Abstract

White lupin (*Lupinus albus*) is one of four economically important species of the *Lupinus* genus, and has been traditionally cultivated for several thousand years along the Nile valley, including in Ethiopia. An experiment comprising of 143 Ethiopian White lupin landraces and one genotype from Germany was undertaken at Merawi in Ethiopia. The objective of the study was to cluster the Ethiopian white lupin accessions into similarity groups and assess the extent and pattern of diversity of the accessions. Data on 10 quantitative agronomic traits were recorded. Landraces were significantly different for most of the traits studied, and a significant number of local accessions performed as high as 5 metric tonnes per hectare of grain yield. Cluster analysis showed that landraces were grouped into seventeen clusters of different sizes, of which five were singletons. Some landraces were grouped together regardless of their geographic origin. On the other hand, landraces from Awji, South Gondar and West Gojam in Ethiopia were distributed over many clusters. Hence, the result did not support definite relationship between geographic diversity and genetic diversity. Genetic distances between many pairs of clusters were significant, justifying crosses between parents from them to be desirable genetic recombinations and, hence, transgressive segregants.

Keywords: Ethiopia, landrace populations, *Lupinus albus*

Paper Number: 1371 (Poster Number: 243)

Feed the Future Innovation Lab for Climate Resilient Cowpea.

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The five-year "Innovation Lab for Climate Resilient Cowpea" began September 2013 under the Feed the Future Global Hunger and Food Security Research Strategy: Climate Resilience, Nutrition, and Policy in the Program Area "High-Yielding, Climate Resilient Legumes". The project involves partnership between the University of California at Riverside and the leading cowpea breeders in four West African nations (Burkina Faso, Ghana, Nigeria and Senegal) in the Sudano-Sahelian region; this is the main production zone for cowpea. The focus is genetics and breeding, with the ultimate aim of increasing yield potential and providing solutions for major production constraints. The areas of emphasis for variety improvement are drought tolerance at critical stages (early seedling, flowering, and pod filling), heat tolerance during reproductive development, and resistance to the fungal pathogen *Macrophomina phaseolina*. There are three basic objectives: 1) Foundation Development, 2) Training and 3) Implementation. Foundation Development includes the improvement of genotyping capabilities. So far, this has included the development of a "60k" BeadAssay iSelect for SNP genotyping which successfully assays 49,393 SNPs, and its application to bi-parental and MAGIC RILs, diverse germplasm, and over 400 West African breeder favorites. One of the outcomes of genotyping bi-parental RILs has been the assignment of over 37,000 SNPs to map positions. Also, the extent of purity and relationships between breeder materials have become evident from analyses of the SNP data. Phenotyping and seed increases are ongoing, and annual workshops ensure the sharing of research advances and the training of people. The project is synergistic with the Feed the Future Legume Innovation Lab, which emphasizes insect resistance in the context of the drought prone production environment.

Paper Number: 1372 (Poster Number: 244)

Bean Varieties Bred, Released and Market Opportunities for Seed Companies in the East and Central African Region.

REUBEN OTSYULA, JOYCE MALINGA and MOSES WAMBULWA, KALRO*

Bean diseases and especially bean root rot causes up to 70% yield loss in commercial bean (*Phaseolus vulgaris* L) cultivars in Kenya. Host resistance is the least costly and most effective strategy for managing bean root rot, particularly for smallholder farmers. Seven resistant varieties have been bred and released to farmers in Kenya, but with limited commercialization. This paper summarizes the recent bean varieties bred for major production constraints and major challenges for marketing at the KALRO-Kakamega and released for commercialization. The studies covered identification of major production constraints and breeding for such constraints resulting in resistant varieties yielding more than 2 tons/ha on station; On farm testing of such varieties for adaptability and farmer preference was done in more than 100 farmer groups with 50-80 farmers each. The role of the breeder in seed production and commercialization. Currently the varieties are licensed to more than 5 seed companies with high seed production. In 2014, about 5 tons of breeder seed and 10 tons of basic seed were produced with a projection of 12 tons in 2015; while in 2015, 500 tons of certified seed of 2 varieties were sold; The potential and opportunities for improved high yielding bean varieties to be commercialized in other countries and expected impact has also been indicated.

Key words: *Phaseolus vulgaris*, resistance, bean root rot, testing advanced lines, seed production, yield potential, commercialization

Paper Number: 1373 (Poster Number: 245)

Breeding for a Fast Cooking Bean: Study of Genotypes Across Environments to Determine Phenotypic Stability in *Phaseolus vulgaris*.

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Dry beans (*Phaseolus vulgaris*) are an inexpensive and nutrient dense food high in protein, fiber, and vitamins. In developing countries, especially in East Africa, beans are a dietary staple, but require a long cooking time before consumption. Considerable cook time variation exists, but little is known about the genetics behind these differences.

Two Andean lines from Tanzania, TZ-27 (PI146755) and TZ-37 (PI661767), have similar seed types, but TZ-27 requires twice as long to cook compared to TZ-37. These lines were grown in 12 environments. Cooking time was measured with a pin drop cooker on unsoaked and soaked seeds. When seeds were cooked after soaking, genotype ($p < 0.0001$), environment ($p < 0.0001$), and a genetic by environmental interaction ($p = 0.0066$) significantly affected cooking time. When soaked, TZ-37 consistently cooked faster than TZ-27; demonstrating that cooking time has a strong genetic component. In contrast, for seeds cooked without a pre-soaking step, environmental effects were observed ($p = 0.0185$), but genotype was no longer significant ($p = 0.2398$). A difference in cell wall enzymatic activity could explain why cooking time differences were observed only after soaking. Work is currently underway to determine if differences in enzymatic activity exists between TZ-27 and TZ-37. Cook time results from these lines represent early work into elucidating what areas of the genome are responsible for cooking time. Faster cooking beans would decrease the time required for gathering firewood and cooking. Additionally, burning less firewood reduces the damaging effects to local and global air quality.

Paper Number: 1374 (Poster Number: 246)

Amenability of Cowpea (*Vigna unguiculata*) to Micronutrients (iron and zinc) Enhancement Using Conventional Method.

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*Amenability of cowpea (*Vigna unguiculata* L. Walp) to micronutrients (iron and zinc) enhancement using conventional method*

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Abstract

About 60% and 30% of the world's population are iron (Fe) and zinc (Zn) deficient, respectively. As an essential elements for human well-being, enhancing cowpea with Fe and Zn will improve the livelihood of more than 200 million consumers mostly women and children. The study is aimed at determining the amenability of cowpea to increase in iron and zinc concentration using conventional method. Grain protein, Fe and Zn concentrations of 50 cowpea accessions were quantified by the micro-Kjeldhal and atomic absorption spectrophotometry. Also 148 F3 lines derived from a cross between TVu-14845 and TVu-15251 low and high zinc parents, respectively, were evaluated under screen house conditions in Zaria, Nigeria (11° 17.0 N and 7° 36.01E). Significant differences were observed for grain protein content (1.72-29.93%); iron (10.01-131.64mg/kg) and zinc (1.01-164.80mg/kg) concentrations. Results of correlation analysis indicates the reliability for direct selection for zinc concentration through selection for large seeded grains. Significant ($P < 0.05$) correlation between zinc concentration and pod yield suggests that selection for pod load will lead to selection for low zinc content. These results demonstrate the feasibility of biofortification of cowpea for these important micronutrients.

Key words: Cowpea; Biofortification; Livelihood

Paper Number: 1375 (Poster Number: 247)

Screening for Alectra Resistance in Cowpea Germplasm Under Greenhouse Conditions in Malawi.

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Alectra vogelii remains an important constraint to cowpea production and productivity in Malawi. Breeding for Alectra resistance (AR) is considered the most effective and economically viable solution to the constraint. Two of the three cowpea varieties grown in Malawi are susceptible to Alectra and some promising germplasm has not been screened for AR resistance. Identification of sources of resistance is, therefore, key to the effort and strategy of AR breeding. In the current study, 15 cowpea lines, received from International Institute for Tropical Agriculture (IITA), and four promising germplasm from Bunda were screened for AR under greenhouse conditions. The objective was to determine their reaction to four different (Bunda, Neno, Mchinji and Kasungu) sources of Alectra collections. The results show differential reaction of the four Alectra collections indicating both sources of resistance and differences in Alectra collections. Mkanakaufiti, a previously released Alectra resistant variety, maintained good resistance. However, additional sources of resistance were detected in B301, IT 89 KD-288, IT 98 K-216-44, IT 97 K-499-35, IT 98 K - 205- 8, IT 99 K- 573-2-1 and IT 00 K 1217. The forms of resistance varied from delayed Alectra emergence, lower Alectra populations, reduced vigour and growth to premature death (before seed production). The new sources of resistance will provide valuable parental lines for incorporating AR to susceptible but preferred and adapted cowpea varieties currently being grown in Malawi.

Paper Number: 1376 (Poster Number: 248)

The Potentials of Phosphorus and Nitrogen Fertilization at Varied Doses to Suppress Striga Parasitism in Cowpea Production, How Promising?.

Lucky O Omoigui, Deborah Folake Ayeni and Joseph Ikwebe, Federal University of Agriculture*

Striga gesnerioides is a notorious parasitic weed constituting a major constraint to cowpea (*Vigna unguiculata*) production and productivity in sub-Saharan Africa. It germinates in response to a naturally secreted chemical, strigolactone, contained in the root exudates of its host. Several control strategies have been proposed, of which, the principal focus is the development of resistant cultivars being the most efficient and cost effective option. However, the variation in virulence, emergence of new races and break down of resistance has necessitated the need for the optimization of other effective control measures to build a robust and integrated management approach to *Striga* menace. This study evaluated the potentials of phosphorus at varied doses (0, 20, 40, and 60kg P₂O₅ ai/ha) as a component strategy to reduce the severity of *Striga* parasitism. Reaction of genotypes to *Striga* was also determined using SSR marker. The result of this study showed that sole application of phosphorus fertilizer did not effectively reduce *Striga* parasitism as reported in other crops but the combination of nitrogen (15kg N ai/ha) and phosphorus fertilization at increasing rates significantly reduced *Striga* parasitism. Highest reduction was recorded at 60kg P₂O₅ per ha but grain zinc content was significantly reduced at the same rate. This strategy can complement other control measures to reduce *Striga* parasitism in cowpea. Further study needs to be carried out to determine the actual role of P in the down-regulating strigolactone production.

Paper Number: 1377 (Poster Number: 249)

Phenotypic Evaluation and Genome Wide Association Studies of Two Common Bean (*Phaseolus vulgaris*) Diversity Panels Highlight Evaluation Techniques, Traits and Lines Useful for Trait Based Selection.

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All authors part of USAID FtF Innovation Lab for Climate Resilience in Beans. Common bean (*Phaseolus vulgaris*) productivity is constrained by abiotic soil conditions including drought and low fertility as well as by high temperature. High temperature primarily impacts pollen viability and growth. Soil water content and nutrients occur heterogeneously and often in a stratified pattern. Multiple shoot and root phenotypes can be used to differentiate and identify genotypes and resistance mechanisms that are related to increased productivity in yield-limiting environments. Phenotypic and/or genetic selection can then be used in a trait based selection and breeding pipeline. We conducted replicated field trials of Andean and Meso-american common bean diversity panels in six locations over two years. Growing conditions included terminal drought, intermittent drought, low phosphorus and low nitrogen. Phenological and agronomic data including yield were collected in all environments, while a customized phenotyping cart was used in two environments to collect geo-referenced canopy height and temperature. Root architectural analysis was conducted at three locations. Samples for analysis of root hair length and density were taken from field and laboratory grown samples. Data indicates significant genotypic variation in performance under different conditions, but several lines excelled in multiple environments. Phenotyping efforts suggest canopy temperature depression and root architecture are involved in edaphic stress tolerance and pollen shed is critical for tolerance to high temperature. GWAS results indicate these traits are controlled by many loci of small effect. The collaborative based phenotyping platforms implemented by this project are likely to highlight selectable traits and genotypes in other species.

Paper Number: 1378 (Poster Number: 250)

Gene Pyramiding for Improvement of Resistance to Major Diseases of Common Bean (*Phaseolus vulgaris*).

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Productivity of the common bean (*Phaseolus vulgaris* L.) is greatly affected by ravages of a combination of fungal, bacterial and viral diseases. Resistance to key diseases is additive in nature and is greatly influenced by the environment. Furthermore, the casual organisms of most of diseases are highly variable, further complicating resistance breeding efforts. Gene pyramiding that entails stacking multiple genes in one variety so as express simultaneous resistance is one way of breeding broad and durable resistance into common beans.

Paper/Poster Abstracts

This paper reviews finding of four gene pyramiding programs i) three resistance genes to anthracnose (*Colletotrichum lindemuthinum*) and one resistance gene to pythium root rot (*Pythium ultimum*), ii) four resistance genes to angular leaf spot *Pseudocercospora griseola* and iii) six resistance genes to angular leaf spot, bean common mosaic necrotic virus (BCMV), anthracnose and pythium root rot, iv) four genetic factors for resistance to Fusarium root rot (*Fusarium solani* fsp. *phaseoli*). Sequence characterized amplified regions (SCAR) and Simple Sequence Repeats (SSR) markers, were utilized in the gene pyramiding schemes. Epistasis between genes was shown to influence the expression of different genes. Lines with pyramided genes were more effective as parents in transferring combined resistance to susceptible cultivars than the individual sources implying their utility as breeding parents for multiple disease resistance. However, negative correlations between the number of pyramided genes and several agronomic traits imply a possible yield penalty. Our findings highlight the need for simultaneous selection for yield parameters and disease resistance and the value of using pyramided lines as parents in disease resistance breeding programs.

Paper Number: 1379 (Poster Number: 251)

G X E Effects in Haulm Fodder Quality Traits and Their Relationships with Grain and Haulm Yield in 50 Cowpea Genotypes.

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Cowpea haulms as legumes are valued as quality fodder and are a widely traded commodity. Haulm yields and haulm fodder quality have both significant effects on livestock productivity. Assessing the variations in the fodder quality traits, their heritabilities and their correlation with to grain and fodder yield provides a good entry point for breeders and livestock nutritionists to identify, promote and design breeding strategies to promote dual purpose genotypes. Fifty genotypes of cowpea cultivated across five locations in Nigeria over two consecutive years 2013-14 were evaluated for haulm fodder quality traits, relationships between haulm traits with grain and haulm yields and broad sense heritabilities. Haulm fodder quality traits were analyzed by a combination of conventional laboratory techniques and Near Infrared Reflectance Spectroscopy (NIRS). Nitrogen (1.5 to 2.5%), in vitro metabolizable energy (ME 8.2 to 8.8 MJ/kg) and organic matter digestibility, IVOMD (57 to 61%) were significantly ($P < 0.05$) influenced by genotypes, locations and years. Trade-off effects between grain yield and haulms fodder quality traits were largely absent though haulm nitrogen and grain yield tended to be inversely associated ($r = -0.26$, $P = 0.07$). Haulm fodder quality and haulm yield were mostly ($P < 0.05$) positively correlated. Broad sense heritabilities for haulm nitrogen, ME and IVOMD were 0.67, 0.67 and 0.61 respectively, suggesting that selection and breeding for haulm fodder quality is feasible.

Paper Number: 1380 (Poster Number: 252)

AMMI Model Analysis of Stability and Adaptability of Drought Tolerant Andean Bean Genotypes in Eastern and Central Kenya.

Eliezah Maina Kamau, Kenya Agriculture and Livestock Research Organization*

AMMI Model Analysis of Stability and Adaptability of drought tolerant Andean bean Genotypes in Eastern and Central Kenya *Kamau, E. M.1 Karanja D. 2 Mbugua, G.W1 and Kihara, S.N.1 1KALRO Kandara, Po Box 220-01000 Thika, Kenya; 2KALRO Katumani, P. O. Box 340-90100 Machakos, Kenya To mitigate the effect of drought in the marginal areas of Eastern and Central regions of Kenya, there is need to develop new market preferred bean genotypes which can cope with the prevailing limited moisture. This study evaluates stability and yield performances of 22 large seeded drought Andean bean (DAB) lines in five environments of eastern, central and rift valley regions during April to June 2015 season. Completely randomized block design with three replications was used per environment. AMMI (additive mean and multiplicative interaction) ANOVA analysis revealed significant (P

Paper Number: 1381 (Poster Number: 253)

Fast Tracking Micro Rich-Nutrient, High Yielding and Marketable Climbing Bean Types in the Northern Highlands of Tanzania.

John W.J. Msaky, Selian Agricultural Research Institute (SARI)*

Paper Number: 1382 (Poster Number: 254)

Introduction of Micro Rich-Nutrient, High Yielding and Marketable Climbing Bean Types in Tanzania.

*John W.J. Msaky**, Selian Agricultural Research Institute (SARI)

Declining arable land and land degradation in traditional bean growing areas pose a threat to the livelihoods and food security of households in Tanzania. Climbing beans with yield potential 2-4 times than bush beans, present the most viable option for enhancing agricultural productivity in such areas. The climbing bean varieties grow well in high lands (> 1,500 masl) where there is high and reliable rainfall with 1,200 - 1,500 mm per year. The high population density in these areas put pressure on the available arable land, hence, farmers are would gain more by planting climbing beans due to their higher productivity per unit of land. Three climbing bean types (Selian 05, Selian 06 and Cheupe) have already been recommended in Tanzania for farmers' production since 2005 and 2006. These medium to small seeded bean varieties are farmer preferred for their high yields. However, their color and grain size are not market-preferred. Besides, Selian 06 is very susceptible to BCMV. Using crop suitability model micro-nutrient rich, high yielding and heat tolerant Mid Altitude Climbing (MAC) lines were introduced at ARI-Selian from Rwanda and were evaluated in 2013 at SARI. In 2014, the varieties were evaluated by farmers and traders in different agro-ecological zones in Babati district. MAC 44 exhibited good performance and exceptional market attributes preferred by farmers and traders. Proper management of the micro-nutrient rich bean varieties, will likely lead to increased bean production in highland areas with land scarcity, improve health status of bean consumers and increase farmers' incomes.

Paper Number: 1383 (Poster Number: 255)

Interspecific Hybridization of Cowpea (*Vigna unguiculata* (L.) Walp.) and Wild *Vigna* Species.

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Statement of problem

Cowpea, (*Vigna unguiculata* [L.] Walp. is a cheap source of protein in the daily diet of people in sub-Saharan Africa. Crop Wild Relatives (CWR) are often sources of genes for resistance to disease and insects of cowpea. Cross incompatibility between wild *Vigna* species and cultivated cowpea is a limitation to the utilization of the useful genes for cowpea genetic improvement. Inter-specific hybridization potentials and cross compatibility with cowpea of many of the wild *Vigna* species are yet to be ascertained.

Key Findings

This study attempted inter-specific hybridization between some wild *Vigna* species found to be resistant to *Striga gesnerioides* and cowpea *Vigna unguiculata*. TVu-8, a land race accession susceptible to striga and IT99K-573-1-1 an improved cowpea variety resistant to striga were both crossed with eleven accessions of the striga resistant wild *Vigna* species belonging to *V. ambacensis*, *V. pakeri*, *V. mungo*, *V. marina*, *V. racemosa*, *V. dekindtiana*, *V. oblongifolia*, *V. reticulata*, *V. glabrescens* and *V. vexillata* in order to ascertain their cross compatibility. The F1 pod obtained was retained for up to three days when TVNu-892 (*V. glabrescens*) served as the pollen parent in a cross with TVu-8, while one pod was retained each from the crosses between TVNu-73 (*V. vexillata*) with TVu-8 and IT99K-573-1-1 when TVNu-u 73 served as the pollen parent. SSR markers only confirmed true interspecific hybridization between TVNu-1824 (*V. dekindtiana*) with TVu-8 and IT99K-573-1-1.

Statement of the overall significance of findings

The result confirms cross compatibility of *V. unguiculata* with *V. dekindtiana* genotypes and their prospect for utilization in cowpea improvement breeding programs.

Keywords: cowpea, genetic diversity; genetic resources; genetic erosion; wild *Vigna* species;

Paper Number: 1384 (Poster Number: 256)

Adaptability of Micro Rich-Nutrient for Enhancing Food Security, Nutrition, Income to Cope with Climate Change in Tanzania.

*John W.J. Msaky**, Selian Agricultural Research Institute (SARI)

Declining arable land and land degradation in traditional bean growing areas pose a threat to the livelihoods and food security of households in Tanzania. Climbing beans with yield potential 2-4 times than bush beans, present the most viable option for enhancing agricultural productivity in such areas. The climbing bean varieties grow well in high lands (> 1,500 masl) where there is high and reliable rainfall with 1,200 - 1,500 mm per year. The high population density in these areas put pressure on the available arable land, hence, farmers are would gain more by planting climbing beans due to their higher productivity per unit of land. Three climbing bean types (Selian 05, Selian 06 and Cheupe) have already been recommended in Tanzania for farmers' production since 2005 and 2006.

These medium to small seeded bean varieties are farmer preferred for their high yields. However, their color and grain size are not market-preferred. Besides, Selian 06 is very susceptible to BCMV. Using crop suitability model micro-nutrient rich, high yielding and heat tolerant Mid Altitude Climbing (MAC) lines were introduced at ARI-Selian from Rwanda and were evaluated in 2013 at SARI. In 2014, the varieties were evaluated by farmers and traders in different ago-ecological zones in Babati district. MAC 44 exhibited good performance and exceptional market attributes preferred by farmers and traders. Proper management of the micro-nutrient rich bean varieties, will likely lead to increased bean production in highland areas with land scarcity, improve health status of bean consumers and increase farmers' incomes.

Paper Number: 1385 (Poster Number: 257)

Development of a Molecular Marker to Track APA Introgression in Common Bean for Bruchid Resistance.

*Lucy Lund*1, Jim Beaver2, Timothy Porch3 and Phillip McClean1, (1)North Dakota State University, (2) University of Puerto Rico Mayaguez, (3)USDA-ARS*

In common bean (*Phaseolus vulgaris*), the main seed storage pests are the bruchid beetles (*Acanthoscelides obtectus* and *Zabrotes subfasciatus*). Adult females lay eggs on the outside of the seed, and the larvae hatch and bore into the seed to feed. Damage done to the seed by the larvae has a large impact on seed quality and yield. Arcelin (ARC), phytohaemagglutinin (PHA), and α -Amylase inhibitor (α -AI) make up a group of linked seed storage proteins that form the APA locus on chromosome Pv04. This locus is associated with bruchid resistance in common bean and tepary bean (*Phaseolus acutifolius*). A major breeding objective is to introduce bruchid resistance into common bean from a resistant tepary genotype, G40199, by introgressing the resistant APA locus into susceptible common bean backgrounds. Here we developed a molecular marker that can be used to track the introgression. A group of four resistant (containing the G0199 APA locus) and four susceptible genotypes were used as source materials to develop the marker. A set of primers to the α -amylase inhibitor locus amplified a DNA fragment that showed a 45 base pair insertion/deletion that distinguished the common bean and G40199 APA loci. The insertion in the resistant line corresponds to a 15 amino acid sequence insertion in the G40199 resistant α -AI protein that is not present in the susceptible lines. This in-frame insertion is located in the lectin domain and may affect the α -AI expression pattern in resistant genotypes. The marker may allow screening for bruchid resistance in early generations.

Paper Number: 1386 (Poster Number: 258)

Molecular Diversity of Nigerian Cowpea Landraces.

Adenubi Adesoye, University of Ibadan and Innocent Iseghohi, Federal University Oye Ekiti*

Statement of the Problem: Cowpea (*Vigna unguiculata* L. Walp.) ($2n=2x=22$) has a narrow genetic base hence is the need to broaden it through diversity study of landraces so as to group them into heterotic groups for effective breeding purpose. Previous studies have only looked at the genetic diversity between selected landraces in Nigeria not within landraces. This formed the major focus of this work. It is suggested that the centre of diversity of cowpea is the northern part of Nigeria. Therefore, this work was designed to study the genetic diversity of cowpea landraces from the derived and guinea savannah agroecological zones of Nigeria with the key objectives of determining the genetic diversity between and within landraces; and the phylogenetic relationship between old and newly collected landraces. Eight cowpea landraces from eight different states in the agroecological zones were collected from the genetic resource centre (GRC) of the International Institute of Tropical Agriculture (IITA) and the genebank of The National Centre for Genetic Resources and Biotechnology (NACGRAB) for the study. Findings: Fifteen simple sequence repeat (SSR) primers designed to amplify cowpea regions were screened to obtain six polymorphic primers for the study. 2 to 4 alleles with mean allele frequency of 2.833 were detected across the loci. The polymorphic information content (PIC) of the markers which tells how informative the markers were ranged between 0.25 and 0.628 with a mean of 0.4149. The mean gene diversity across the loci was 0.4753. The cluster analysis based on UPGMA, Nei's genetic distance and analysis of molecular variance (AMOVA) gave consistent results of the genetic diversity of the landraces between and within the agro ecological zones, as well as the states of collection. The diversity between the landraces contributed 70% while within the landraces accounted for 30% of the total genetic diversity of the population. Significance of the Findings: This is significant for the up-to-date characterisation and the distinct grouping of the existing cowpea germplasm in the studied zones for effective breeding program in increasing yield and better quality cowpea seeds.

Paper Number: 1387 (Poster Number: 259)

YIELD Stability and Farmer Preference of Bean Lines (*Phaseolus vulgaris*, L.) in Different AGRO-Ecological ZONES in Malawi.

*James Bokosi*1, Lowinzie Sibande1, Vincent Saka1 and Rowland Chirwa2, (1)Lilongwe University of Agriculture and Natural Resources, (2)International Center for Tropical Agriculture (CIAT)*

Common beans, *Phaseolus vulgaris*, L is an important crop in Malawi, both nutritionally and economically. However, yields and productivity remain low due to numerous biotic and abiotic constraints. A multi-environmental trial was conducted in 2013/14 season to evaluate yield stability and farmer' preference of 14 advanced breeding lines plus two recommended varieties as checks over five sites representing three agro-ecological zones in the Country. A randomized complete block design was used. GLM and ANOVA were used to analyze the data, DMRT was used carry out multiple mean comparisons and AMMI was used to test stability analysis of the bean lines. A Participatory Variety Selection (PVS) exercise was also carried out to let farmers choose their best cultivar based on the attributes they saw in the field. There was across environment promising performance from DC 96-69, UCD 0233, F11 MDRB (B) 25, F11 MDRB (B) 24, F3 MDRB (A) 8 and DG 226 with yields of more than twice that of the current recommended varieties, Kalima and Bwenzilaana. Preference test, as revealed by participatory variety selection (PVS) protocol indicated that the most preferred lines were F11 MDRB (B) 24, DG 226, (6) F5 PS 04-120 (A) MAS and DC 96-69. The ability to produce more pods per plant, tolerance to diseases and bigger grain size were among the desired varietal attributes. On the contrary, vulnerability to diseases, smaller grain size, fewer number of pods per plant and dull seed colour were the most disliked varietal characteristics by farmers.

Key words: *Phaseolus vulgaris*, yield stability, common bean, participatory variety selection

Paper Number: 1388 (Poster Number: 260)

Grain Yield Stability of Cowpea Genotypes in Contrasting Environmental Conditions in Southern Mozambique.

*Rogério Marcos Chiulele*1, Acaccio Jose Alfredo2, Lucas Mauro Chiau1 and Teodoro Mainote Chale1, (1) Eduardo Mondlane University, (2)University of Zambeze*

In Southern region of Mozambique crop yields are very unpredictable mostly due to high intra and inter-seasonal and spatial rainfall variability combined with variable pest and diseases pressure. Assessing yield stability in this region is crucial for identifying best performing genotypes across the region. A study was conducted to assess yield stability of 12 cowpea genotypes to variable environmental conditions in Southern region of Mozambique. The experiments were alpha-lattice designs arranged in 3 rows and 4 columns with 4 replications. Detection of GxE was done using the Residual Maximum Likelihood (REML) and its quantification and stability analysis were performed using GGE biplot from R software package. Genotype by environment interaction was present. This GxE was of cross-over type indicating that genotypes performed differently to the change in environmental conditions. Genotypes UC-CB-46 was high yielding and adapted to all environments while INIA-152, INIA-41 and IT98K-1105-5 were high yielding but with adaptation to specific environments. Of the total of environments used to evaluate varieties, Chókwe was the most discriminating environment. Genotypes UC-CB-46 is recommended to be cultivated under variable environmental conditions in southern Mozambique comprised of irrigated, water stressed and farmer managed conditions. INIA-41 was best performing under farmer managed condition while INIA-152 was best performing under farmer managed as well as irrigated and stressed conditions of Umbeluzi. The study revealed that in Southern Mozambique, yield can be predictable using genotypes such as UC-CB-46.

Paper Number: 1389 (Poster Number: 261)

Caracterização De Acessos De Feijão Feijão Boer (*Cajanus Cajan* (L.) Millspaugh) Colectados Em Moçambique.

Marques Cachisso Bambo Donca, Mozambique Agrarian Research Institute*

A grande variabilidade genética presente no germoplasma de feijão boer (*C. cajan* (L.) Millspaugh) em uso na agricultura familiar tem sido plenamente reconhecida. A eficiência da conservação e o aproveitamento desta variabilidade aumentam quando esta é devidamente caracterizada. O presente trabalho foi conduzido com objetivo de caracterizar o germoplasma colectado em duas regiões de produção do feijão boer em Moçambique, avaliar a correlação entre as variáveis, similaridades e dissimilaridades entre os acessos, bem como determinar qual o componente do rendimento possui maior contribuição na produtividade de grãos. Os experimentos foram realizados no Instituto de Investigação Agrária de Moçambique em Nampula, durante as campanhas de 2012/2013 e 2013/2014, foi utilizado o delineamento de Lattice, parcialmente balanceado em 3 repetições e avaliados 81 acessos. Os dados foram colectados utilizando o manual de descrição de feijão boer (IBPGR/ICRISAT, 1993) e do catálogo de germoplasma de feijão boer. Foi realizada a correlação entre as variáveis e o agrupamento dos principais caracteres utilizando a técnica de optimização de Tocher.

Os resultados mostraram que o número de ráculos por planta, ramos secundários e terciários foram os que maior contribuíram para o aumento do rendimento. Por outro lado, a análise de agrupamento mostrou que os acessos avaliados formaram 5 categorias distintas, permitindo inferir que existe divergência entre os acessos avaliados. Estes materiais que estão adaptados a região, poderão servir para futuros trabalhos de melhoramento e seleção de cultivares para uso dos próprios produtores. Caracterização de Acessos de Feijão boer (*Cajanus cajan* (L.) Millspaugh) Colectados em Moçambique, Marques Donça & Higino André

Paper Number: 1390 (Poster Number: 262)

Identification of New Sources of Resistance to Common Bacterial Blight in Beans in Uganda.

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ABSTRACT The common bean (*Phaseolus vulgaris* L.) is a legume grain crop with great importance in East Africa, especially in Uganda, as a source of food and income for most rural households. Common bacterial blight (CBB), caused by *Xanthomonas axonopodis* pv. *phaseoli* (Xap), is an economically important disease of common beans causing yield losses of 20-75%. Since chemical control is ineffective, the use of resistant cultivars is an important management strategy. This study aimed to identify new sources of resistance to Xap concurrent with improving CBB resistance in locally adapted common bean varieties of Uganda. Eighty genotypes tested included 65 from the Regional Nutritional Nursery, 10 lines from an interspecific cross (*P. coccineus* x *P. vulgaris*, coded ALB) and 5 sources documented for CBB resistance (coded VAXs). These were screened twice for CBB resistance in a screen-house using the Fuscans variant of *Xanthomonas campestris* pv. *phaseoli* (Xcpf) isolate, "Kawempe 1" at a concentration of 5x10⁸ cfu/ml. Cultivars RW 846, VAX 5 and RWV 1129 were most susceptible to CBB, and JESCA, RWV 2070, MIB 456, and MCM 2001 most resistant. These four locally adapted varieties could replace the exotic sources of resistance long used in most African CBB breeding programs. Genotypes KAT 39, KAT 31 and MONTALCAM had low CBB scores combined with early flowering, high pod number, and high seed weight, while JESCA and MIB 456 also performed well for number of pods and seed yield. Thus, these genotypes can be exploited for both CBB resistance and increased yield.

Paper Number: 1391 (Poster Number: 263)

Cowpea (*Vigna unguiculata* (L.) Walp.) Landrace Diversity in Ethiopia.

*Berhanu Amsalu Fenta**, Ethiopian Institute of Agricultural Research, Melkassa Agricultural Research Centre

Although Vavilov indicated as Ethiopia is a secondary center of diversity for cowpea, there is limited information regarding genetic resource, major production challenges and social factors related to cowpea production. For this reason, cowpea baseline survey have been conducted to assess landrace diversity and ethnobotany of cowpea in the country using semi-structured interview, field observations and market surveys. A total of 94 cowpea landraces and representative voucher specimens have been collected from different geographical locations ranging in altitude from 428 – 2439 m.a.s.l. Accordingly, Ethiopian cowpea collections can be grouped as: *Vigna unguiculata* subspecies *dekintiana*, subspecies *cylindrica*, subsp., *cylindrical* (L.) Verdc, and subsp. *Unguiculata*. Further under this study, the collected landraces have found to be diverse in seed sizes, colors, and growth habits. In the northern Ethiopia, majority of farmers (75%) preferred the erect type of cowpea because of its early maturity, feed value, adaptable to diverse soil, disease and drought tolerance. Baseline information about production system, constraints and utilization have been also collected. For instance, in the northern Ethiopia form the total of respondents, about 49% of cowpea was produced as a sole crop and 35% as intercropping and 16% both sole and intercropping system. Cowpea as a food can be prepared in different form boiled grain, mixed with cereals and baked bread, dried, roasted and grinded powder can be used to prepare sauces and the leaf, young and tender pod used as vegetable. This study generally gave substantial firsthand information about cowpea production status and landraces in the country.

Paper Number: 1392 (Poster Number: 264)

Adaptabilidade e Estabilidade Das Concentrações De Ferro e Zinco Em Genótipos De Feijão-Caupi Na Região Nordeste Do Brasil.

*Maurisrael de Moura Rocha*1, Diêgo Sávio de Vasconcelos Oliveira2, Kaesel Jackson Damasceno-Silva3, José Ângelo Nogueira de Menezes Jr.3, Marília Regini Nutti4 and Luis José Duarte Franco1, (1)Embrapa Meio-Norte, (2)Universidade Federal do Piauí, (3)Embrapa Mid-North, (4)Embrapa Agroindústria de Alimentos*

Adaptabilidade e estabilidade das concentrações de ferro e zinco em genótipos de feijão-caupi na região Nordeste do Brasil Maurisrael de Moura Rocha¹, Diêgo Sávio de Vasconcelos Oliveira², Kaesel Jackson Damasceno-Silva¹, José Ângelo Nogueira de Menezes-Júnior¹, Marília Regini Nutti³, Luis José Duarte Franco¹ 1Embrapa Meio-Norte, Av. Duque de Caxias, 5650, B. Buenos Aires, Teresina, PI, Brasil, 64006-220 2Universidade Federal do Piauí, Campus Universitário Ministro Petrônio Portella, Bairro Ininga, Teresina, PI, Brasil, 64049-550 3Embrapa Agroindústria de Alimentos, Av. das Américas, 29501, B. Guaratiba, Rio de Janeiro, RJ, 23020-470 O feijão-caupi (*Vigna unguiculata* L. Walp.) apresenta grande importância socioeconômica na região Nordeste do Brasil.

Contém alguns minerais que promovem benefícios à saúde humana. O desenvolvimento de cultivares biofortificadas em ferro e zinco pode ajudar no combate à desnutrição em populações com uma dieta inadequada. No entanto, esses caracteres são muito influenciados pelos efeitos de ambientes e da interação genótipos x ambientes (GA). O objetivo desse trabalho foi selecionar genótipos para adaptabilidade e estabilidade das concentrações de ferro e zinco no grão. Foram conduzidos ensaios com 12 genótipos em três locais da região Nordeste do Brasil, em delineamento de blocos ao acaso, com três repetições. As análises das concentrações de ferro e zinco no grão foram realizadas pelo método de digestão nitroperclórica e leitura em espectrofotômetro de absorção atômica de chama. Utilizou-se a estatística Pig proposta por Lin e Binns e Pif e Pid de Carneiro para avaliar a adaptabilidade e estabilidade dos genótipos. Os resultados mostraram a existência de contrastes entre os locais para ambos os minerais; no entanto, a interação GA foi significativa apenas para a concentração de zinco. A concentração de ferro variou de 43 mg kg⁻¹ a 64 mg kg⁻¹, enquanto a concentração de zinco, de 37 mg kg⁻¹ a 54 mg kg⁻¹. A cultivar BRS Xiquexique apresentou adaptabilidade e estabilidade geral e adaptação específica a ambientes favoráveis para as concentrações de ferro e zinco, enquanto as linhagens MNC04-769F-31 e MNC04-769F-45 mostraram melhor adaptação a ambientes desfavoráveis, respectivamente, para as concentrações de ferro e zinco. Palavras-chave: *Vigna unguiculata*, microminerais, interação genótipo x ambiente, previsibilidade.

Paper Number: 1393 (Poster Number: 265)

Research and Development of Bambara Groundnuts: Prebreeding Efforts in Zimbabwe.

*Busiso Olga Mavankeni**, Crop Breeding Institute

Bambara groundnut (*Vigna subterranea* L. Verdc.) is a crop with a lot of potential to contribute to food and nutrition security in Zimbabwe. It has high protein content (17-23%) with high levels of methionine and lysine. The major constraints faced by farmers in Zimbabwe in the production of Bambara groundnut include the long maturity duration exhibited by the crop, unavailability of improved disease resistant, early maturing high yielding varieties. In an effort to resuscitate the national bambara programme in Zimbabwe, a germplasm collection expedition was carried out in 2014. The germplasm was collected from agricultural shows, seed fairs and individual farmers. A total of 82 distinct morpho types were realised. The landraces exhibited differences in seed colour and growth habit among other traits. The landraces were found to be variable in a number of traits and variability is the cornerstone of any breeding programme. These landraces have been cultivated for many years and therefore can be used in the improvement of bambara groundnut. The exhibited variability can be further explored in developing and structuring a breeding programme in Zimbabwe. Further more some of the landraces can be purified and released as purelines for use by farmers whilst efforts to further select for attributes such as disease resistance, early maturity and high yield are being explored. Promotion and production of bambara groundnut in Zimbabwe can enhance food and nutrition security in the small holder sector in the advent of climate change. Bambara groundnut landrace variability breeding.

Paper Number: 1394 (Poster Number: 266)

EARLY Size Selection for YIELD and SEED Traits in Cowpea Breeding.

*Marques Cachiso Bambo Donca**, Mozambique Agrarian Research Institute

Abstract The purpose of this study were to examine the effect of early selection on seed size in a cowpea segregating population on grain yield in more advanced generations and to estimate the effect of the progeny x location interactions on success in selection. Two inbred lines differing in seed size, both with white-colored seeds, were crossed. The F1 generation was backcrossed with one of the parents and progressed to the F3 generation. In the F3 generation, the seeds were divided into two samples. In one of them (Ps), selection was carried out for seed size, with only seeds retained in the 7 mm sieve being kept, and in the other (Pn), with no selection. These two subpopulations were bulked up and advanced to F5 generation. In this generation, 97 F5:6 progenies were removed per subpopulation. The 194 progenies, together with the two parents, were evaluated in Teresina (F5:6) and Lavras (F5:7). Estimates of the genetic and phenotypic parameters obtained showed that early selection for traits related to seed size does not affect the success of selection in more advanced generations for grain yield. The progeny x location interactions was expressive for some traits, with predominance of the complex type, especially for grain yield. Early selection permitted that with the same effort dedicated in relation to population without selection, it was possible to obtain progenies in F5:6 and F5:7 that associated higher mean grain yield with higher proportion of seeds retained in the 7 mm sieves, which is highly desirable. EARLY SIZE SELECTION FOR YIELD AND SEED TRAITS IN COWPEA BREEDING Marques C. B. Donça*; Magno A. P. Ramalho; Francisco R. Freire Filho M. C. B. Donça, Instituto de Investigação Agrária de Moçambique, Caixa Postal 3618, Maputo, Moçambique, DARN, Programa de Leguminosas e Oleaginosas de grão. M. A. P. Ramalho, Universidade Federal de Lavras, Caixa Postal 3037, CEP 37200000, Lavras- Brazil, DBI, Programa de Pós Graduação em Genética e Melhoramento de Plantas. F. R. Freire Filho, Empresa Brasileira de Pesquisa Agropecuária, Teresina/PI Brazil, CEP: 64006-220, Melhoramento de feijão caupi. *(mcdonca2001@gmail.com)

Paper Number: 1395 (Poster Number: 267)

Evaluation of Common Bean (*Phaseolus vulgaris*) Genotypes for Resistance to Root Rot Disease Caused By *Pythium Aphanidermatum* and *Pythium Splendens* Under Screen House Conditions.

*Papias Hongera Binagwa**, *Selian Agricultural Research Institute, Conrad Bonsi, Tuskegee University and Susan Nchimbi, Sokoine University of Agriculture*

The most important economic species of the genus *Phaseolus* is the common beans (*Phaseolus vulgaris* L.) which is widely cultivated and arguably the most significant leguminous for direct human consumption. Root rot disease caused by *Pythium* pathogen is one of the major production constraint in bean growing areas within East Africa. In Tanzania, control measures used by farmers are fungicidal seed treatments which are less effective and not environmentally friendly, soil drainage and crop rotation which are not sustainable in the disease management. The response of common bean genotypes to *P. aphanidermatum* and *P. splendens* and their interactions were statistically different ($P < 0.0001$). Two bean genotypes ADP-014 and ADP-080 showed promising trait of resistance, 38 genotypes showed moderate resistant trait and 57 were susceptible to *Pythium* root rot disease. This study discovered two source of genotypes that have a promising trait of resistance against *Pythium* root rot disease and can be used in breeding scheme. Once a resistant genotype is identified it potentially used regardless of specie or species combinations that are present, allowing for a wider control of *Pythium* root rot disease through improved host resistance across the major common bean growing regions. Further studies should focus on field evaluation under natural disease pressure, several screening experiments and introgressing of gene of resistance into farmer's market class cultivars.

Key words: Genotypes, Leguminous, Pathogenic, *Pythium*, Resistant trait and Screening

Paper Number: 1396 (Poster Number: 268)

Evaluation of Medium Duration Pigeon PEA Lines for YIELD Potential, Disease Tolerance and Adaptability in Malawi.

*Esnart Yohane**, *Department of Agricultural Research Services*

EVALUATION OF MEDIUM DURATION PIGEON PEA LINES FOR YIELD POTENTIAL, DISEASE TOLERANCE AND ADAPTABILITY IN MALAWI E. Yohane¹, GAD Kananji², Ganga Rao³, D. Siyeni¹, E. Mazuma¹ and O. Madzonga³ ¹Department of Agricultural Research Services, Chitedze P.O. Box 158, Lilongwe ²Alliance for Green Revolution in Africa, P/Bag B343, Lilongwe ³ICRISAT Malawi, Chitedze Research Station, P.O. Box 1096, Lilongwe ICRISAT Kenya, P.O Box 39063, Nairobi, Kenya Pigeonpea (*Cajanus cajan* (L.) Millsp.) is a very important legume in Malawi for food and cash income. The crop is also capable of replenishing soil fertility through biological nitrogen fixation. Although the crop is mainly grown in Blantyre and Machinga Agricultural Development Divisions (ADDs), there is great potential to expand production in traditionally non-pigeon pea growing areas especially in the central and northern regions of the country. This is happening because efforts made by the Department of Agricultural Research (DARS) in partnership with ICRISAT have led to the development and release of improved medium maturing pigeon pea varieties that are photo-period insensitive with reduced maturity period. In the 2014/15 growing season, 12 advanced pigeon pea lines were evaluated at three locations for yield, tolerance to *Fusarium* wilt disease and adaptability in a randomized complete block design with three replications. The trial plots were 5 ridges, 5 m long and ridges were 90 cm apart. Yield and phenological data were collected including disease scores on *Fusarium* wilt incidence. Genstat 16th Edition computer package was used for data analysis. Results showed significant variations in days to maturity among the test lines suggesting that some lines took longer to mature than others. ICEAP 01154/2 took less days (159 d) to reach 95% physiological maturity compared to the check variety or varieties (Mwayiwathualimi and Mthawajuni) across the sites. High significant yield differences (P

Paper Number: 1397 (Poster Number: 269)

Assessment of Stability, Adaptability and Yield Performance of Common Bean (*Phaseolus vulgaris* L.) Genotypes Under Multi-Environment Conditions in Zimbabwe.

*Bruce Mutari**, *Crop Breeding Institute*

The stability and adaptability of common bean genotypes can be affected by environmental variability which results in relative ranking differences of genotypes across locations. The aim of this study was to identify genotypes with high adaptability and stability using the methodologies of Finlay and Wilkinson, Nin and Binns, Wricke's ecovalence and Additive Main Effects Multiplicative Interaction (AMMI) Fifteen genotypes were tested across five rain-fed environments for 2 seasons (2010–2011). The experiments were laid out in a Randomised Complete Block Design with three replications. To determine the effects of genotype, environment and genotype by environment interactions (GEI) on grain yield, data were subjected to analyses of variance using the Breeding Management System statistical analysis software. The genotypes, environments and GEI accounted for 5.2%, 84% and 10.9% of the total sum of squares (SS) respectively. Regarding the mean yield, MG38 and VTTT925/9/1/2 were the best performing followed by NUA45 and Gloria. Lin and Binn's index revealed that MG38, Gloria and VTTT925/9/1/2 combined dynamic stability with high mean performance across locations.

Paper/Poster Abstracts

The analysis of adaptability and stability using AMMI and Wricke's ecovalence stability coefficient methodologies identified genotypes, Gloria, Dark 146, Iris and Natal sugar as the most stable. Genotypes ARA4, SEQ1040 and PAN148 were identified as the most unstable by Lin and Binns index, AMMI and Wricke's ecovalence methodologies. MG38 and VTTT925/9/1/2 are more stable and are recommended for release. There is need for breeders to consider the stability of varieties before release because high yielding genotypes are not always stable across locations.

Paper Number: 1398 (Poster Number: 270)

AMMI and GGE Biplot Analysis of Cowpea (*Vigna unguiculata*) Advanced Lines for the Semi-Arid Region of Kenya.

*Rose Wangari Kuruma**, Kenya Agricultural Research and Livestock Organization

AMMI And GGE Biplot Analysis Of Cowpea (*Vigna unguiculata*) advanced lines for the Semi-Arid Region of Kenya Kuruma, R. Wangari 1* and Muriuki, C Kahwaga. 2 1, 2 Kenya Agricultural Livestock and Research Organization – Katumani, P.O Box 90100-340, Machakos, Kenya. Email: kungurw@yahoo.com Abstract The genotype by environment interaction manipulates the selection criteria in multi-purpose crop like cowpea. This study was conducted to determine the adaptation of new advanced generation cowpea lines, quantify the magnitude of the genotype by environment interaction effects on cowpea grain yield and determine the winning genotypes for the test environments. Thirty cowpea breeding lines were evaluated at four locations located at different agro-ecological zones of Kenya. The genotypes were grown in randomized complete block design with three replicates during the 2014 and 2015 seasons Yield data was analysed using the additive main effect and multiplicative interaction model (AMMI) and GGE biplot. The AMMI analysis of variance for grain yield detected significant effects for genotype, location and genotype by location interaction effects. The most stable genotype in the high yielding group in this study was G5 (1005/1002/1/1/1), followed by G19 (1005/100/2) and G23 (1002/1005/3). The G5 could be used for broad selection since it was found to be the most ideal genotype with both high mean yield and high stability in comparison to other genotypes. The GGE biplot identified 2 mega-environments for growing cowpea. The results of this study indicated that the cowpea grain yield performance is greatly influenced by genotype by environment interaction effects. Keywords: - Genotype by environment interaction, AMMI, grain yield, stability, cowpea

Paper Number: 1399 (Poster Number: 271)

Genetic Studies of Winter Hardiness in Pea.

*Courtney Holdt**, North Dakota State University

ABSTRACT

Production of dry pea has been important and ranks third among legumes around the globe due to their high protein content and ability to symbiotically fix atmospheric nitrogen. Pea production is typically as a spring-sown crop, but in some countries (i.e. Australia) the crop is fall-sown. Many areas in Europe and North America at the higher latitudes are interested in planting more of the pea crop in the fall to avoid adverse conditions in the spring sowing period. Fall sowing allows the pea crop to avoid high summer temperatures experienced and often results in increased seed production. In order to take advantage of the benefits from fall sowing in the higher latitudes that traditionally experience extreme cold winter temperatures genotypes which are capable of surviving the winter conditions are necessary. This research aims to aid the development of winter hardy peas by developing improved screening methods to identify increased levels of cold hardiness. Phenotypic evaluation in controlled setting and development of a genetic map of the genes necessary for cold hardiness are key components of this research. The mapping of cold hardiness genes will aid in a more holistic understanding of the pea genome for further breeding. Development of improved protocols and molecular tools to detect cold hardiness in controlled environment will increase the productivity of breeding programs focused on cold hardiness.

Paper Number: 1400 (Poster Number: 272)

Responses of Cowpea Genotypes to Rock Phosphate Application.

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Cowpea (*Vigna unguiculata*(L.) Walp.) plays an important role in the livelihood of people in Sahel and Savanna regions of Sub-Saharan Africa. However, phosphorous (P) depletion is one of the constraints of its low productivity. Farmers cannot apply enough fertilizer because of inadequate supplies and lack of access to credit. Therefore, pot experiments were conducted to know the efficiency of the indigenous rock phosphate (RP) for cowpea cultivation under low P conditions. Shoot dry weight (SDW) at 8 weeks after seeding (WAS) had a significantly high correlation with P uptake ($r = 0.817$, $P < 0.01$). The rates of decrease of SDW from the control 30 mg P kg⁻¹ (as KH₂PO₄) to 171 mg P kg⁻¹ as RP (34% P₂O₅) were calculated.

Sixteen lines of the 28 tested genotypes obtained lower rate than the overall mean (22.6%). Seven of these lines showed a significant high SDW compared with IT97K-499-35 that had the lowest value. For four of the seven positive responder lines (Iron bean, IT87D-941-1, IT97K-499-38, and Danlla), their SDWs at 8 WAS in 57 mg P kg⁻¹ or more were significantly higher than those with zero application. Their grain yield (GY) tended to be higher with 57 mg P kg⁻¹ or more, compared with zero application. Based on these results, at the least, RP application of 57 mg P kg⁻¹ is necessary to enhance SDW and GY of good responder lines. This indicated the high possibility to establish reasonable production system to improve cowpea production.

Paper Number: 1401 (Poster Number: 273)

Relationships Between Yield and Its Components for Common Bean (*Phaseolus vulgaris* L.) in Burundi.

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Abstract

Knowledge of relationship among yield and the other agronomic characters is important in plant breeding, especially for the individual plant selection. The objective of this study was to assess the correlation coefficient and carry out path analysis between seed yield and its components. The experiments, in split split plot with three replications, were carried out in Burundi during 2013A and 2013B cropping seasons. Eight biofort common bean genotypes were assessed including a released variety taken as a control (GLP2). Direct and indirect effects of the yield components on seed yield were analyzed using path coefficient analysis. Seed yield was most affected by the number of days to 50% flowering and plant height in both 2013A and 2013B cropping seasons. Correlation analysis showed that seed yield was significantly affected by plant height (0.690***), pods per plant (0.660***), seeds per pods (0.380***), as positive and negatively affected by the number of days to Physiological maturity (-0.193**) and the weight of 100 seeds (-0.280***) during 2013A whereas it was effected significantly affected by plant height (0.278***) as positive and negatively affected by the number of days to physiological maturity (-0.281**) during 2013B. Combined correlation analysis over locations and seasons indicated that DFL was highly correlated with DPM (0.74*** and 0.606***) due to its indirect effect. Thus importance should be given for the above traits while selecting bean crop. According to the path analysis, plant height was the most important due to direct effect on the increase of seed yield on selection studies. Thus, this could be used as a selection criterion in dry bean breeding for high yield.

Résumé

La connaissance des relations entre le rendements et d'autres caractères agronomiques est important en amélioration des plantes, spécialement dans la sélection individuelle d'une plante. L'objectif de la présente étude était d'évaluer le coefficient de corrélation et de dégager le path analysis entre le rendement et ses composantes. Le dispositif expérimentale en split split plot avec trois répétition a été conduit au Burundi durant les saisons agricoles de 2013A et 2013B. Sept génotypes de haricot biofort ont été évalués en plus d'une variété améliorée de l'ISABU prise comme témoin. Les effets directs et indirects des composantes du rendement sur le rendement ont été analysés à l'aide du path coefficient analysis. Durant les deux saisons, la hauteur des plantes et le nombre de jours à 50% de floraison se sont montrés comme des composantes déterminant du rendements. Au cours de la première saison culturale, l'analyse de la correlation a montré que le rendement a été positivement affecté par la hauteur des plants (0.690***), nombre de gousses par plants (0.660***), nombre de grains par gousse (0.380***) et négativement par le nombre de jours à la maturité physiologique (-0.193**) et le poids de 100 graines (-0.280***). Par contre, au cours de la deuxième saison, le rendement était positivement affecté par la hauteur des plants (0.278***) et négativement affecté par le nombre de jours à la maturité physiologique (-0.281**). L'analyse combiné à travers les sites et saisons a montré que le nombre de jours à 50% de la floraison par son effet indirect était positivement corrélé avec le nombre de jours à la maturité physiologique (0.74*** and 0.606***). Ainsi, une grande importance peut être attribuée à ces dernières lors de la selection variétale. A travers les résultats du path analysis, la hauteur des plants s'est révélé être la plus importante par son effet direct dans l'augmentation du rendement. Par conséquent, il peut être utilisé comme critère de sélection dans l'amélioration du haricot avec but d'augmenter le rendement.

KEY WORDS: *Phaseolus vulgaris* L., Bean, seed yield, yield components, correlations; path analysis, Burundi.

Paper Number: 1402 (Poster Number: 274)

Evaluation of Cowpea Mutant Varieties in Comparison with Conventional Varieties.

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Title: Performance of cowpea mutants in comparison with conventional bred cowpeas varieties in Zambia

Breeding process in general requires significant amount of resources in both budgetary allocation and time. Mutation breeding for desired traits can offer cost effective tool to developing required cowpeas varieties. During the 2008 season in Zambia Agriculture Research Institute four improved cowpeas varieties with documented characteristics submitted to University of Zambia for blasting with irradiation. The aim of the irradiation was to achieve the traits of economic/agronomic importance in cowpea varieties for small-scale production. These are order of priority: pest tolerance, seed size/colour, and grain and leaf yields, earliness, and tolerance to existing soil tress. The first generation planted in replicated field trials showed some desired traits apart from yield compared to the four parents. These traits were seed colour, earliness, tolerance to soil stress and size of the leaves. The second season the trials was planted in replicated trials in two locations, Msekera research Station during the main rain season and advanced during the off-season under irrigation.

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Observations taken showed some differences though insignificant due to the design of the trial. In the third off-season there were significant differences observed in earliness, biomass production and yield. In the fourth season the promising varieties were successfully evaluated in multilocal trials at Msekera, Kabwe, Masumba and Golden Valley Research Stations. By the fourth season two varieties have been selected and are being evaluated in National Variety Trials for release. It is possible to reduce the evaluation of cowpea varieties from seven in the conventional breeding program to fast-track to four-five years development process with mutation breeding thereby reducing the cost. These superior varieties have, however, have to be evaluated on economic/culinary benefits and other subtle traits

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Paper Number: 1403 (Poster Number: 275)

Progress in Common Bean (*Phaseolus vulgaris* L.) Improvement for Major Diseases in Ethiopia: Marker Assisted Selection (MAS) to Deploy Multiple Disease Resistance in Common Bean Varieties for Ethiopia.

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Common bean (*Phaseolus vulgaris* L.) is one of the most important grain legumes in Ethiopia, and produced in all the regional states with varying intensity. Although traditionally food and nutritional security crop in Ethiopia, its importance as source of foreign currency and cash income for smallholder farmers is increasing. The productivity of this important crop under farmers' condition is below 0.6 tons/ha, which still is low as compared to the crop's potential yield (up to 4.5 tons/ha). Among a number of factors that could attribute to the low achieved yield, diseases especially common bacterial blight (*Xanthomonas campestris* pv *phaseoli*) (CBB) and angular leaf spot (*Pseudocercospora griseola*) (ALS) pose a significant harvest loss in common bean at farmers field. Therefore, developing bean varieties with improved and durable resistance to biotic stresses is the primary goal of the bean breeding program. To facilitate selection of resistance bean lines the applications of molecular markers in the breeding program is fundamental. Molecular markers have been implemented in marker assisted parallel backcrossing (MABC) breeding program to deploy CBB and ALS resistance gene/QTLs in to the farmer preferred but susceptible bean varieties. The use of molecular markers like (SU 91, SAP6 and g796) allowed breeders in early selection of bean lines resistance to one or more pathogens currently part of the breeding program. Currently the breeding program at SARI, Ethiopia has been progressing in implementing MABC in deploying multiple disease resistance genes/QTLs in popular farmer preferred red and mottled but susceptible common bean varieties targeting varieties which are durable resistance for the important pathogens so as to increase the productivity of this important crop.

Paper Number: 1404 (Poster Number: 276)

Genotype x Environment Influence on African Yam Bean (*Sphenostylis stenocarpa*) Antinutrients.

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Statement of the Problem: The presence of antinutritional factors (ANFs) alongside hardness to cook has been identified as reasons for the neglected and under-utilized status of African yam bean (AYB), a protein rich legume. Various researchers have focused on ways to reduce these ANFs. However, breeding varieties of AYB with low levels of these ANFs offers a more satisfactory long-term solution to this problem. The aim of this research, therefore, was to determine the influence of genotype and environment on tannins, phytic acid, trypsin inhibitors, and haemagglutinin content of fifteen genotypes of AYB grown in three different locations- Abakaliki (6°19' N 8°6' E), Enugu (6°52' N 7°37' E) and Ibadan (7°26' N 3°53' E).

Findings: Variability in the levels of these ANFs in AYB depended largely on the environment where they are grown. Genotype x environment was significant for all the antinutritional factors while genotype effect was strongest in controlling haemagglutinin content. Abakaliki was the safest environment for AYB production while TSs 58 had the lowest levels of TI and haemagglutinin. More work needs to be done on these to further reduce the antinutritional factors.

Significance of Findings: The implication of these findings is that an AYB genotype grown and safely consumed in an environment could have antinutritional effects when grown and consumed in another environment. Results also suggest the existence of sufficient variability in TI activity, tannins and haemagglutinin activity in these AYB genotypes and a high possibility of lowering their levels in AYB seeds in a carefully designed genetic improvement programme. It is recommended that an expanded multi-local testing of AYB genotypes be conducted.

Paper Number: 1405 (Poster Number: 277)

Agrobacterium-Mediated Transformation and Development of Cry1Ac Transgenic Cowpea Lines.

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Cowpea is one of the economically important grain legumes used for food and feed throughout the tropical world. Farmers have suffered significant yield losses as well as losses during storage due to insect pests indicating an urgent need for enhancing insect resistance in cowpea. In this study, we used a transformation approach to introduce B.t.-toxin gene Cry1Ac as the gene of interest. A major problem with cowpea transformation is the lack of a universally applicable transformation protocol. Therefore the present study was done with the objective of optimizing transformation conditions (media, media supplements, explant type and explant positioning) through assaying GUS transient expression and the development of transgenic cowpea lines expressing a construct containing a cry1Ac gene for pod borer resistance and a bargene for herbicide tolerance as selectable marker. Cowpea transformation was affected by inoculation/incubation media, medium supplements and explant type. Better transformation efficiency was obtained with a medium containing Na-thiosulphate, high concentrations of acetosyringone and decapitated embryonic explants. The way the explant was positioned on the incubation media affected the surface of the explant expressing the GUS transgene having an implication on how to place the explant to enhance transformation efficiency particularly on shoot producing area of the explants. Using the optimized conditions, a number of putative transgenic lines were obtained. PCR, RT-PCR and leaf paint functional analyses showed the integration, expression and functionality of the transgene in few of the primary transformants. Seeds were collected from the transgenic lines for further molecular, segregation and functional analyses. The confirmed transgenic lines could be very useful for subsistence farmers in many African countries who suffer a lot from pod borer attacks. As we used an herbicide resistance gene instead of antibiotic resistance, the environmental release of the developed transgenic lines for production might be straight forward once all the necessary molecular, biochemical and functional analyses are done. The result of this study highlights the recalcitrance of cowpea to in vitro conditions and the need for further study to optimize a more efficient protocol for cowpea transformation.

Key words: cowpea, insect resistance, transgene, cry1Ac, bar and transformation

Paper Number: 1406 (Poster Number: 278)

Arcelin-Containing Bruchid Resistant Navy Beans As Future Potential Variety to Enhance White Bean Production.

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Navy beans are mostly produced in Ethiopia as one of exportable commodity. Although it has significantly contribute to enhance the income of small holder farmers and the national economy, the productivity is still relatively low owing to several biotic and abiotic stresses. Especially, post-harvest problem (bruchid attack) has found to be one of the major constraint for the farmers and to the exports. To tackle these problems it has been hypothesized as there could be a possibility to generate superior navy beans varieties having bruchid resistance. Multi-environment trials was conducted using arcelin-containing inbred lines (RAZ lines) imported from CIAT/PABRA at eight locations for three years. Accordingly, the analysis of variance revealed that the overall mean yield performance of three RAZ lines (RAZ-42, RAZ-11 and RAZ-119) with 2t/ha and 12% exceeded the standard check Awash 1. These lines were also found to exhibit combined resistance to major diseases (CBB, HB, angular leaf spot and anthracnose) across tested sites. The resistance of bruchid resistance of these lines have been also confirmed by exposing these lines for bruchids at laboratory infestation. Moreover, the presence of arcelin-containing gene have been also confirmed through SSR marker analysis. Testing the cook ability and also canning quality of the RAZ lines has also shown promising result. Therefore, these promising lines have been recommended for verification for national release. Hence, the output of this trial is unique in white pea production history in the country and would also has a potential to contribute for the development navy beans.

Paper Number: 1407 (Poster Number: 279)

Genetic Diversity of Ethiopian Cowpea (*Vigna unguiculata* (L.) Walp.) Accessions Based on Microsatellite Markers.

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Abstract Ethiopian cowpea (*Vigna unguiculata* (L.) Walp.) genetic relationships were little studied and to analyzed the association of the genetic diversity, 210 genotypes representing 189 accessions plus 21 subtypes and 23 microsatellites. The average genetic diversity (D), as quantified by the expected heterozygosity, was 0.47. A total of 75 alleles were defined with the average number of alleles per locus was 3 and a total of two rare alleles were registered when screened with SSR1 marker. The mean polymorphic information content was 0.4. Our results indicated that the accessions were not grouped according to their geographical origins.

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Three main cluster groups were identified, and the sub-groups identified by phylogeny tree were in accordance with the clusters revealed by the structure and principal component analysis. This grouping was with high fixation index value of 0.075 and gene flow (Nm) of 3.176, indicating the accessions possess wide diversity within both individuals and populations. Institute of Biodiversity and Conservation (IBC), Ethiopia should reorganize their seed stock by considering the subtypes identified in our research results. The present study also detected promising five accessions from Amhara, Gambella and SNNP regions, tightly clustered and shared a common allele with the multi-race striga resistant accession B301; this could help in identification of appropriate parental lines for Striga resistance. The rare alleles identified were linked to desirable trait of striga resistance against Striga gesnerioides, SG3 RACE. The finding showed that the genetic base of Ethiopian cowpea is narrow and can be enhanced through introduction of accessions with desirable alleles.

Keywords: Cowpea, Genetic diversity, SSR, Ethiopia germplasm, Striga

Paper Number: 1408 (Poster Number: 280)

On station Evaluation of Four Types of Pigeon Pea Varieties for Small-Holder Farming Systems.

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Title: Evaluation of Four Pigeon pea varieties types for the small-holder production system in Zambia

Pigeon pea is an important new crop in the small-holder farming systems. In Zambia the crop is not widely cultivated despite its involving potential in soil, crop and livestock interfaces. However despite years of evaluation there are only two medium duration varieties that have been released. Since 1988 Msekera Research Station, Ministry of Agriculture, in partnership with ICRISAT and recently with APPSA has evaluated the extra short duration varieties with 60 days to mature, short duration with 90 days to mature, Medium duration with 150 days and the long duration with 260 days to mature. All this would fit into the diverse farming systems of a small-holder farmer. A series of on station trials therefore have been evaluated for mainly grain yields. The extra short duration might not fit into the small-scale farming system because of their intense spraying regime. Whereas the short duration are competing with the other crops like maize, and groundnuts while the medium duration hold promise because they don't compete on labour while the long duration would have a niche in the maize/pigeon pea intercropping and soil restoration systems. As a result of this work a number of varieties have been found to be suitable for commercial production. This has been identified based on their consumer/market preferences-grain colour/size and processing quality. However, there is still need to carry out systematic evaluation on yield, processing quality, while accelerating seed systems for this crop

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Paper Number: 1409 (Poster Number: 281)

Identification of New Sources of Resistance to Striga Gesnerioides in Cowpea Accessions Using Morphological and Molecular Tools.

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The parasitic weed, Striga gesnerioides is major threat to cowpea production and productivity in the savannas of West and Central Africa. Thus, identification of Striga gesnerioides resistant genes and their incorporation into breeding programs would be the most successful strategy to combat the parasite in cowpea fields. However, breeding for resistance to S. gesnerioides is faced with a challenge of the existence of a few resistance sources that have poor agronomic characteristics and often are not well adapted to environmental conditions in Nigeria. There have also been reports of breakdown of Striga resistance in previously resistant cowpea cultivars in Nigeria. This could be attributed to new Striga races emerging or to an increase in the aggressiveness of current Striga races therefore necessitating identification of new sources of resistance to S. gesnerioides. To this end, one hundred and ninety-four (194) accessions, four commercial varieties and two controls collected from a mini core collection of the International Institute of Tropical Agriculture genebank were assessed for resistance to Striga using phenotypic screening and molecular marker techniques. Results of the studies revealed that two cowpea accessions, Tvu-1272 and Tvu-16514 were resistant to S. gesnerioides. The resistance status was confirmed with molecular markers. Complete resistance was expressed as a hypersensitive response of infested root tissue. The allelism test indicated that the gene that confers resistance in Tvu-1272 is independent of that which confers resistance to B301. Tvu-1272 and Tvu-16514 will provide additional new sources of resistance to Striga race prevalent in Nigeria.

Paper Number: 1410 (Poster Number: 282)

Participatory Variety Selection of Canning Beans in Ghana.

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Beans importation to Ghana increased from less than 18 tonnes to a little over 139 tonnes between 2008 and 2011. Beans imported included fresh or chilled, dried beans, dried kidney beans and canned beans. Common bean consumption in Ghana has increased over the years in the form of imported baked beans sold in supermarkets located in the urban areas and small shops in villages. Diagnostic market survey conducted in Kumasi and Ejisu, revealed that, all super markets and most small retail shops sold baked beans. Demand for baked beans has increased due to urbanisation and increased incomes which call for convenient and quality foods. Price of canned beans ranged from \$1.00 to \$1.25 per 400g tin. More than 8 brands of baked beans were found in a supermarket. At the inception of PABRA and CIAT in 2010, more than three hundred common bean accessions have been received for evaluation for adaptation, seed yield, tolerance to diseases and pests, and other agronomic traits in Ghana. Eighteen canning bean lines were selected after 3 years of evaluation. These lines were further evaluated in 5 locations. Seed yield ranged from 417 to 1622 kg ha⁻¹ in 2014. Participatory variety selection (PVS) was organized to let consumers, extension agents, researchers and farmers select varieties of their choice to establish the preferences of consumers. More than 70 % of the participants irrespective of their gender chose 6 bean lines as their most preferred beans. Ranking of the preferences of the 6 varieties varied based on gender. Canning bean most preferred by women was G53 followed by G73. The men however, preferred G 87 followed by G 53.

Key words: Beans, selection, participatory, yield

Paper Number: 1411 (Poster Number: 283)

Field Performance of Andean Diversity Panel Lines in Two Locations in Tanzania.

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Common bean (*Phaseolus vulgaris* L.) is the most important grain legume in human diets in East Africa. For example, it is estimated that over 75 % of rural households in Tanzania depend on it for daily dietary requirements. Despite its importance, bean yield in the East African region is among the lowest in the world with an average of about 0.717 t/ha. Both biotic and abiotic factors contribute to the observed low yields in the region. In addition, most farmers do not have access to improved bean varieties due to unsatisfactory seed distribution systems for legume crops. The Andean Diversity Panel was evaluated in two locations, for two seasons in replicated trials in Tanzania. The objectives of the evaluations were to identify lines that would perform well under field conditions and later on be used in the breeding programmes for improvement. Disease and yield data were collected and analysed. Twelve ADP lines were found to perform well consistently in two seasons, and in two locations. These lines will be further evaluated in on-farm trials in the coming seasons and their cooking traits will also be assessed. It is expected that some lines from these twelve will be identified which could be used in the breeding programmes or be released for use by farmers.

Paper Number: 1412 (Poster Number: 284)

Recurrent Selection for Drought Tolerance in Cowpea.

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The low adoption of technologies by farmers and the occurrence of biotic and abiotic stress limit the production of cowpea in semiarid regions. The tolerance of cultivars to water deficit is one way to decrease the negative effects of stress on yield. Because it is a complex trait, the use of recurrent selection is more effective in achieving genetic gains. The aim was to evaluate the recurrent selection efficiency for generating cowpea segregating populations tolerant to water deficit. It was performed a complete diallel involving six cowpea genotypes (BRS Paraguaçu, BRS Xiquexique, Pingo de Ouro-1-2, Santo Inácio, CNCx 689-128G e MNC99-510F-16). Were obtained 30 F2 populations (population base – S0), of the first cycle of recurrent selection. Were selected 219 families S0:1 by principal components analysis, which together with six parents composed the experiments conducted in 15 x 15 simple lattice. 50 populations were selected and evaluated by two years consecutives (S0:2 e S0:3). All populations were evaluated under water deficit during the reproductive phase, being applying half the water depth required by cowpea (180 mm). The additive effects were more important and was verified presence of maternal inheritance. BRS Xiquexique, Pingo de Ouro-1-2 and MNC99-510F-16-1 genotypes, were the most promising for use in recurrent selection aiming water deficit tolerance.

The average of the top five progenies selected in the S0:3 was 1700 kg ha⁻¹, higher than the average of the parent of 1172 kg ha⁻¹. These findings contribute to reducing production losses caused by drought, especially in the arid regions.

Paper Number: 1413 (Poster Number: 285)

Selection for Short Day Adaptation, Disease Resistance, POD Quality and YIELD in Vegetable Runner Bean.

Mable Mercy Mulanya, University of Nairobi*

Abstract Vegetable runner bean's (*Phaseolus coccineus* L.) production and utilization in Africa is severely constrained by reliance on imported long-day varieties which require additional artificial lighting to trigger flowering and pod formation under tropical short-day conditions. The objective of this study was to select for short-day adaptation, pod quality and yield from runner bean bulk populations. 114 F6.8 lines were evaluated in 2013 and 34 lines in 2014 at two locations (Kabete, 1800m.a.s.l and Ol Joro-Orok 2300m.a.s.l) in Kenya. Data was collected on days to 50% flowering, number of racemes per plant (each raceme had 15 single flowers), disease resistance, marketable pod yield, length and diameter. The fresh pods were categorized as Grade I, II and III according to commercial standards. Analysis of variance showed that there were significant differences (P

Paper Number: 1414 (Poster Number: 286)

Evaluation of Cowpea Mutants for Tolerance to *Callosobruchus Maculatus*.

Langa Tembo, University of Zambia*

Cowpea (*Vigna unguiculata* (L) Walp) is an important grain legume pulse in sub-Saharan Africa. It is an important quality source of protein especially for resource poor farmers who cannot afford animal protein. Yields have been characteristically low as a result of both abiotic and biotic stresses. Among the biotic stresses infestation by bruchids (*Callosobruchus maculatus*) is a major problem which can cause yield losses of up to 100%. To alleviate this problem, use of resistance varieties is a feasible and cheaper approach. One way of creating variation to aid in identifying resistant genotypes is by the use of mutagens in mutation breeding. The objective of this study therefore, was to evaluate mutants for tolerance to *Callosobruchus maculatus* in cowpea. In this study 8 genotypes (mutants and their parents) and 2 other popular genotypes (Musandile and Namuseba) were used. These were planted in January 2015 in three locations (UNZA, GART and Msekera) in Zambia using a RCBD with three replications. Storage evaluations were done in the Laboratory at the University of Zambia. Two male and two female bruchids were put in each petri dish presenting a specific location, genotype and replication. Number of eggs laid and adults emerged were recorded. The results obtained showed that there were significant differences ($p < 0.01$) among locations with regards to mean adults emerging across genotypes. While variations among genotypes with regards to number of adults emerging were not found significant, the interaction between genotypes and location was highly significant ($p < 0.01$). There was also a strong correlation (0.93) between number of eggs laid and Number of adults emerged. The mutant LT 11-5-2-2 was identified to be tolerant and it out performed its parent in all the three locations.

Paper Number: 1415 (Poster Number: 287)

Morphological Characterization and Evaluation of Cowpea [*Vigna unguiculata* (L.) Walp.] Genotypes for Seed Traits in South Africa.

Abe S Gerrano, Willem S Jansen van Rensburg, Patrick O Adebola and Sonja L Venter, Agricultural Research Council-Vegetable and Ornamental Plant Institute*

Morphological characterization and evaluation of cowpea [*Vigna unguiculata* (L.) Walp.] genotypes for seed traits in South Africa Abe S. Gerrano*, Willem S. Jansen van Rensburg, Patrick O. Adebola and Sonja L. Venter Agricultural Research Council-Vegetable and Ornamental Plant Institute Private Bag X293, Pretoria 0001, South Africa Abe S. Gerrano*, PO Adebola and WS Jansen van Rensburg Agricultural Research Council-Vegetable and Ornamental Plant Institute, Private Bag X293, Pretoria 0001, South Africa INTRODUCTION The seed size of cowpea play a major role in contributing towards increased grain yield. Many consumers in African countries tend to prefer cowpea varieties with larger seeds (Egbadzor et al., 2013). Improvement of seed size as well as other seed characteristics in cowpea genotypes will not only result into increase productivity per unit area but will lead to wider consumer acceptability in South Africa. Hence, the objective of this study was to characterize the seeds of available cowpea genotypes as a first step for the selection of suitable parental genotypes for use in our cowpea breeding program. MATERIALS AND METHODS Seeds of 45 cowpea genotypes were obtained from the germplasm collection of the Agricultural Research Council - Roodeplaat Vegetable and Ornamental Plants Institute (ARC - VOPI) and ARC Grain Crops Institute (ARC-GCI) gene banks in South Africa. The genotypes were grown at the ARC-VOPI (latitude 25.604° S, longitude 28.345° E) research station during 2013/2014 cropping season in a randomized complete block design with three replications. Quantitative data was analyzed by means of ANOVA using Agrobase Generation II (2008).

Data was also subjected to principal component and cluster analyses using the Number Cruncher Statistical System (NCSS 2004). RESULTS AND DISCUSSION The analysis of variance showed highly significant ($p < 0.01$) differences among the cowpea genotypes for all seed traits indicating the existence of high genetic variability among them. Some of the seed characteristics were strongly and positively correlated which indicated these seed trait(s) can be simultaneously selected. The cluster analysis of the seed traits showed four distinct groups of genotypes. This provides a useful measure of genetic distances among the genotypes and enable the identification of potential parental lines for use in future breeding efforts under South African condition. CONCLUSIONS The study provided useful information on the seed morphological and quantitative characteristics of the 45 cowpea genotypes and the relationship among them. This will assist in the selection of suitable parental genotypes in our cowpea seed improvement program. REFERENCES Agronomix, 2008. Agrobases Generation II. Agronomix Software, Inc. 71 Waterloo St. Winnipeg, Manitoba, R3N0S4, Canada. Egbadzor K.F., Dadoza M., Danquah E.Y., Yeboah M., Offei S.K. and Ofori K. 2013. Genetic control of seed size in cowpea (*Vigna unguiculata* (L.) Walp). International Journal of Agriculture Sciences 5:367-371. NCSS. 2004. Number Cruncher Statistical Systems, North 1000 East, Kaysville, Utah 84037, Canada. Key words: Cowpea, seeds, traits, principal component

Paper Number: 1416 (Poster Number: 288)

Quantitative TRAIT LOCI Associated with STEM Strength and Lodging in Dry Peas.

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Field pea is an excellent rotation crop which leaves nitrogen in the soil for the following crop, breaks disease cycles, and facilitates rotational weed control. All new pea cultivars must be resistant to lodging. In order to discover the QTL associated with lodging in peas, a RIL population was created from a relatively wide cross between the commercial variety Delta and a wild type pea variety. Data was collected for 15 quantitative morphological traits and several categorical traits which might be linked to lodging resistance. Based on two years of preliminary data, the major genes influencing lodging in pea are Mendel's dwarfing gene (*le*) and the semileafless mutation (*af*), which together account for approximately 30% of the variation in lodging in pea. Number of basal branches explains approximately 13% of the variation in lodging. Literature has indicated that increasing compressed stem thickness would decrease lodging in pea, but the association appears weak in this population. Compressed basal branch diameter has a weak positive correlation with lodging, indicating that wider stems may increase lodging due to added weight. Multiple pleiotropic effects were seen for such traits such as tendril length, which is positively correlated with plant height, lodging, yield, and tiller diameter. These and other associations need to be investigated further in pea. Genotype by sequencing, SSR markers, and STS markers will be used to discover genetic markers for major traits influencing lodging resistance and other important characteristics in pea, allowing for faster selection of desirable characteristics.

Paper Number: 1417 (Poster Number: 289)

Breeding Dry Bean for Drought Tolerance, Disease Resistance and Canning Quality in Eastern Africa.

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ABSTRACT

Productivity of canning beans in eastern Africa has declined drastically in the last four decades due to susceptibility to drought, diseases and lack of adapted varieties with grain quality characteristics required by the processing industry. The objective of this research was to develop new canning bean lines combining drought tolerance, good agronomic potential with desired canning qualities acceptable to the industry, farmers and seed producers. About 160 advanced bean lines selected from a genetically diverse nursery of 445 advanced lines were evaluated for drought tolerance under moisture stressed and no-stress conditions at Kabete, Thika and Mwea for two seasons. Selected lines were also evaluated for water uptake and cooking time, which are critical characteristics of dry beans destined for the canning industry. Results showed significant differences (P

Paper Number: 1418 (Poster Number: 290)

Conservation and Use of African Orphan Grain Legumes.

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Statement of the problem

Several species of many underused orphan legumes of tropical African origin with edible seed and tubers are economically important while some of them serve as a close substitute for cowpea (*Vigna unguiculata* (L.) Walp). In many cases they are able to thrive on nutrient deficient soils and their ability to break the breeding cycle of endemic pest and diseases. These crops have significant potential but have little research being carried out on them with limited information about their genetic variability thereby limiting the use of available genetic resources for crop improvement.

Paper/Poster Abstracts

Key findings

The Genetic Resources Centre (GRC) of IITA conserves over 2500 accessions of African orphan crops consisting of 13 different species with Bambara groundnut (BG)(*Vigna subterranea*) and African yam bean (AYB) (*Sphenostylis stenocarpa*) constituting more than 80% of accessions. Morphological and molecular tools were used to assess the genetic diversity of some accessions of AYB, BG, Kersting's groundnut (*Macrotyloma geocarpum*) and winged bean (*Psophocarpus tetragonolobus*) while nutrient profiling of selected AYB and BG accessions was carried out.

Overall significance

Understanding the genetic diversity in collections of these crops and their variability for key traits paves the way for pre breeding and breeding programs to develop improved varieties and give smallholder farmers more options in the face of climate change.

Paper Number: 1419 (Poster Number: 291)

Breeding Snap Bean for Domestic and Export Markets in Eastern Africa.

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Breeding for high yield, disease and pest resistance, tolerance to abiotic stresses, general adaptation to tropical conditions and acceptable market quality is a critical component of an integrated strategy to address constraints to snap bean production in the east, central and west Africa. In 2006, ASARECA initiated a regional programme to develop improved snap bean varieties for smallholder production. However, due to funding constraints and lack of skilled personnel, activities in Uganda, Rwanda and Tanzania slowed down, and eventually stopped in June 2007. However, activities continued at the University of Nairobi, where segregating populations were developed. In 2010, promising lines and early generation populations from this program were distributed to programs in five countries (Tanzania, Uganda, Burundi, Sudan and Kenya) in eastern Africa and three countries (Cameroon, Togo and Senegal) in West Africa. In Kenya, more than 647 single plants with combined resistance to rust, angular leaf spot and anthracnose were selected from F5 population bulks. The selected plants were used to establish F5.6 and F6.7 progeny rows in 2011. About 160 lines were evaluated in preliminary, intermediate and advanced yield trials between 2012 and 2014. Results showed that new lines were better yielding (8-18 t ha⁻¹) and more resistant to diseases compared with commercial. Results showed that more than 20 new lines cooked faster, and had longer shelf life and acceptable organoleptic characteristics compared with commercial checks. The first two locally developed snap bean varieties which meet all market demanded traits were released in Kenya in June 2015. Key words: snap bean, pod quality, pod yield, disease resistance

Paper Number: 1420 (Poster Number: 292)

Breeding Fast Cooking Cowpeas for Increased Utilization and Improved Nutrition in Sub-Saharan Africa.

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Long periods of cooking associated with pulses such as cowpea negatively influence their utilization. Long periods of cooking cowpeas lead to loss of nutrients, increased use of firewood and its negative impact on the environment, and loss of useful time. Fast cooking cowpea varieties will help deliver highly nutritious food to the hungry within shorter periods, encourage less use of firewood, improve gender equity, increase the consumption of cowpeas, trigger an increase in demand for cowpeas and thus incentivize cowpea production in Sub-Saharan Africa. Fast cooking improved varieties can be developed through the tool of breeding. However, very little is known about the genetic diversity of cooking time in cowpeas. Thus, the primary objective of this study was to assess the diversity for cooking time in 160 cowpea accessions treated under two contrasting treatments: 'no storage' and storage for 9 months under high temperature and relative humidity. Other objectives were to assess the effect of cooking time on some nutritional properties of cowpeas and to test the ability of using raw seed characteristics to predict cooking time. Cowpea accessions were obtained from Nigeria, Mali, Burkina Faso, Niger, USA and Ghana. Results obtained indicated variability in cooking time with the fastest cooking time of 13 minutes after soaking and a longest cooking time of 575 minutes for the 'no storage' category. The average cooking time for 'no storage' and 'stored' cowpeas were 63 and 268 minutes with a 76.5 % increase in cooking time after storage.

Paper Number: 1421 (Poster Number: 293)

Genetic Analysis of Thrips Resistance in Cowpea (*Vigna unguiculata* [L.] Walp.).

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Abstract

This study assessed the genetic variability for thrips resistance among the cowpea germplasm, determined the mode of inheritance of genes that conferred resistance and estimated both broad and narrow sense heritabilities for the inheritance of thrips resistance in cowpea. Twelve cowpea lines were used in crosses in the screen house at IITA, Ibadan. The mating was accomplished using North Carolina design II to generate 48F1 hybrids, which were eventually evaluated with the parents. Data on number of peduncles, number of pods and number of thrips per flower were recorded and subjected to analysis of variance using random model by SAS 9.2. Significant variability was observed for most agronomic and thrip-adaptive traits among the cowpea germplasm, parental-lines and F1 genotypes evaluated. General combining ability (GCA) and specific combining ability (SCA) mean squares were significant ($P < 0.01$) for pods/plant and other traits under the research environment. The GCA effect accounted for 68.82–80.07 % of the total variation among hybrids for all traits except days to flowering; SCA explained less than less than 50% of the total variation. Narrow sense heritability estimates ranged from 63.92% (peduncle/plant) to 7.53% (days to flower). Additive gene action largely controlled the inheritance of yield components and other traits under thrips infestation and these traits were moderately heritable.

Keywords: North Carolina Design II, gene actions, heritability, and combining ability

Paper Number: 1422 (Poster Number: 294)

The Germplasm Regression Combined (GRC) Association Studies in Linseed (*Linum usitatissimum* L.) Using Microsatellite Markers.

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Germplasm-regression-combined. (GRC) marker trait association can be used as an alternative to marker trait association in planned population. It not only allows mapping of genes/QTLs with higher level of confidence but also allow detection of genes/QTLs. Genetic markers such as microsatellites, the heritable entities that are associated with economically important traits are used by plant breeders as selection tools. Recently several SSR markers are developed in linseed. Hence developing association between these markers and useful agronomic and nutraceutical traits such as Alpha Linoleinic Acid (ALA, precursor of -3 fatty acid) content is possible. The experimental material comprised of 100 linseed (*Linum usitatissimum* L.) germplasm accessions which were diverse in nature both from the point of geographical area and other yield attributing characters. The morphological traits served as dependent variables and the SSR marker data as independent variable. Markers showing significant regression values are considered as associated with the quantitative trait under consideration. A total of 117 alleles were detected for the 50 microsatellite markers, out of which 111 were polymorphic. Polymorphism percentage was 97.14. The number of alleles detected per primer pair ranged from 2 to 5 with an average 2.34. The maximum number of five amplified products were observed in the profile of the primer Lu138, followed by Lub14 and Lu273 having 4 alleles. The primers Lub11 (66.66%), Lub14, Lua47 (66.66%), Lu138 (80%), Lu146 (66.66%) and Lu273 (75%) were proved to be less polymorphic and rest were 100% polymorphic. Significant regression was observed for 8 traits on a total of 21 SSR alleles of the 111 polymorphic SSR alleles. SSR markers Lub11-2 and Lua133-2 were associated with days to maturity at 1% significant level. Number of secondary branches found to have two associated markers (NCL_4-2, Lu236-2). SSR markers Lu144a-1, Lu151-2 and Lu138-4 were associated with number of capsules per plant at 1% significance level. Similarly three SSR markers viz Lua49B (allele number one), Lua60 (allele number one) and Lua125a (allele number three) were significantly associated alpha linolenic acid content at 0.1% significance level ($P \leq 0.001$). Four SSR markers namely Lu151-2, Lua68-2, Lu138-3 and Lu143-1 were associated with 1000 seed weight. SSR markers Lu236-2, Lu144a-1, Lu151-2, and Lu143-2 were significantly ($P \leq 0.001$) associated with seed yield per plant. Lub14-4 and Lu143-1 were associated with oil content in seeds. Above association studies could provide valuable information to screen the germplasm accessions for the specific traits of interest using the linked SSR markers. As the SSR markers used in the present study are not mapped, it is difficult to study population structure at this stage. Therefore, markers identified during the present study need to be validated before using for marker assisted selection for the development of nutraceutically improved, high yielding linseed varieties.

Paper Number: 1423 (Poster Number: 295)

Development of Mapping Population for Early Leaf Spot Tolerance and Best Bet Varieties Seeds Multiplication in Mali.

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Groundnut is one of the most important legume cultivated in all the worldwide. It has a founding uses in both human consumption and forage. This crop has a predominant contribution to food quality for millions of rural families in arid and semi-arid regions of the world particularly in West-Africa. Early leaf spots is one of the major fungal foliar disease largely distributed in groundnut cultivated areas. Early Leaf Spots affect the agronomic performance of groundnut and the yield reduction can exceed 30%. It appears thus primordial to develop new varieties that combine high yield performance adapted to local and tolerance to early leaf spots. Crossing bloc has been set using three tolerant varieties to Early Leaf Spots collected from ICRISAT Bamako and three farmers preferred varieties from IER. Artificial hybridization has been performed for all possible combinations of parental lines. Irrigation facilities has been purchased and set in place for off season activities that are ongoing. Two best bet varieties ICGV 86124 and Fleur 11 preferred by farmers are under irrigation for seeds multiplication in 2 ha at the research station of Samé, Kayes and 0.5 ha at Sotuba research station based in Bamako. The process of purchasing a pick up vehicle for seed system activities in multi-locations is advanced.

Paper Number: 1424 (Poster Number: 296)

Molecular Characterization of Cowpea (*Vigna unguiculata* (L.) Walp.) Landraces Using Simple Sequence Repeat (SSR) Markers.

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Cowpea, *Vigna unguiculata* (L.) Walp plays an important role in the livelihood of some rural households of Sub Saharan Africa and South East Asia where it is used as food, animal feed and as a cash crop. The selection of cowpea varieties to plant by farmers is usually based on traditional or local criteria and attributes; this brings about bias and confusion when large pools of landraces are needed to be screened for probable improvement. These inconsistencies also bring about problems in validating the actual breeder's names of crop varieties adopted by farmers while great genetic potentials are usually locked up in these landraces. Twelve highly polymorphic (PIC= 0.2178 to 0.7762 mean 0.4623) fluorescently labelled cowpea SSR markers were used to genotype 150 cowpea landraces which were collected from Local farmers in Kano State Northern Nigeria. The landraces were group into three cluster and were found to be fairly diverse (Shannon diversity index =0.595, He=0.52). The result indicated that certain collections with the same name which are expected to be genetically related were not, while some other with different names was found to be genetically similar. The screening of these local varieties brought about a clearer understanding of the distribution and nature of the variations within the Kano cowpea landraces. Presence of diversity is sure a key to the development of genotypes with increased yield potential through breeding for desired traits thereby increasing farmer's production and productivity, and finally reducing poverty.

Keywords: Cowpea, SSR marker, genetic diversity

Paper Number: 1425 (Poster Number: 297)

Progress in Cowpea Improvement and Production in Burkina Faso.

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Cowpea (*Vigna unguiculata*) is the most important crop that provides nutritional quality, food security and cash income for the resource poor farmers of Burkina Faso. Cowpea research started in 1978 in order to boost the production estimated at 100 000 tones by increasing the low yield (200 kg/ha) which was attributable to insect pest damage, diseases, low soil fertility, drought, Striga and cropping system. Cowpea production of the country in 2014 was estimated at 675 000 tones. The mean yield has increased (800 kg/ha). This progress is the result of research activities of the multidisciplinary team composed of breeders, entomologists, pathologists, virologists, sociologists, and the financial contribution of our policy makers, International agencies and donors. In our presentation we will discuss the progress made in terms of breeding methods and variety development, crop protection and storage, agronomy, seed production, capacity building and technology dissemination.

Paper Number: 1426 (Poster Number: 298)

Morphological Characterization and Evaluation of Bambara Groundnut (*Vigna subterranea* [L.] Verdc.) Genotypes for Yield and Yield Related Traits.

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Bambara groundnut (*Vigna subterranea* [L.] Verdc.) is an important, but under-utilized legume crop grown in sub-Saharan Africa mostly by resource poor farmers. Landraces of the crop are grown in the region whose genetic diversity has not been evaluated. The objective of this study was to evaluate yield and yield component response of 49 genotypes of Bambara groundnut derived from single plant selections of diverse germplasm collections. Field evaluations were conducted involving 26 yield and yield related traits, using a partially balanced lattice design with three replications. Highly significant (P

Paper Number: 1427 (Poster Number: 299)

An Overview of Chickpea Crop Improvement Program of Ethiopia.

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Chickpea (*Cicer arietinum* L.) is one of the most important food legumes in Ethiopia, grown by over 1 million farm households on 13.2 % the total crop acreage and 14.8% of the total production. The current national chickpea productivity is nearly 1.9 t/ha although this is much low compared with the crop potential 6t/ha. Some of the challenges in chickpea production include extensive use of local landraces with low yield potential, susceptibility to biotic and abiotic stresses, poor crop management practices and insufficiency of high quality seed of improved varieties. Since 1974, chickpea improvement program of Ethiopia has been working on the variability created by collection of local germplasm, introduction, hybridization and selection among other approaches. With the backstopping support of CGIAR Centers, ICRISAT and ICARDA through germplasm exchange, capacity building and collaborative projects (notably TL I, TL II and TL III) the breeding, extension and seed system research has been strengthened. Through this, 16 varieties at federal level and 8 at regional level have been developed and released with their full production packages. These varieties possess superior traits such as high yield and resistant/tolerance to biotic and abiotic stresses besides farmer and market preferences. Innovative integrated seed production and dissemination approaches involving formal, semi-formal and informal systems has led to more than 40% adoption in major intervention areas, with more than double the yields of the landraces. These achievements will be upscaled through TLIII project.

Paper Number: 1428 (Poster Number: 300)

Induced Mutations for Increasing Genetic Diversity in Cowpea (*Vigna unguiculata* [L.] Walp.).

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Dry seeds of eight cowpea accessions were treated with ⁶⁰Co gamma dose rate of 202Gy/min at five different levels (100, 200, 300, 400 and 500Gy). Irradiated seeds from each treatment were planted in pots to raise M1 plants and the harvested seeds were advanced to M2 generation. The M2 plants were screened and scored for mutant phenotypes on the field. Selected mutants were advanced to M3 and M4 generations to confirm their mutant phenotypes and genetic stability. Observed mutation spectra and frequencies varied across cowpea accessions and radiation treatments. New cowpea mutants with novel phenotypic and agronomic traits were selected from five out of the eight accessions used. The frequencies of yellow and white seedling (albino) mutants were higher than other mutants in all cowpea accessions and across radiation treatments. The tall-erect non-branching trait of the mutant IB-ER could be used to develop tall and erect cowpea varieties that may be useful for mechanized farming. Observed mutation rates were higher in IT86D-719, IT86D-1010, IT86KD-374-57 and IT90K-284-2 than in Ife Brown (IB) and its derivatives. The mutants selected in this study can be used for cowpea improvement, genetic analysis, biochemical and physiological studies.

Keywords: Cowpea; mutants; phenotype; morphological; fasciated;

Paper Number: 1429 (Poster Number: 301)

Radio-Sensitivity of Cowpea to Ultra-Violet Radiations By Pollen Treatment.

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Pollen grains harvested from eight cowpea accessions were treated with 30,000 Ws/cm² ultraviolet (UV) radiation for 60, 120, 180, 240, 300 and 360 minutes. The irradiated pollen in each treatment was used to self-pollinate emasculated flowers of the mother plant to evaluate the effects of UV irradiated pollen on seed setting in the M1 generation. Harvested seeds from M1 plants were advanced to M2 generation to evaluate the UV radiation effects on seed germination, plant survival and for mutant selection in the M3 generation. Pollen irradiation with UV rays for a short period (60 min) before pollination increased seed setting in all the cowpea accessions except IB-Y-1 where it reduced seed setting by 28.6%. The LD50 among the cowpea lines was observed within the range of 142.6 min and 210.1 min UV radiation period. No significant difference was observed for the percentage seed germination in all treatments except irradiation for 120 min in IT90K-284-2. A similar trend was observed in percentage seedling survival except in IB-BPC, IT86D-719 and IT86D-1010 where low values were recorded. The three-primary leaf and four-primary leaf mutants observed in the M3 generation reverted back to two-primary leaf seedlings suggesting the presence of certain biochemical mechanisms in plants which may be responsible for the repairs of some UV induced mutations and damages to plant DNA. Low mutation frequencies recorded in this study shows that cowpea is considered less amenable to the application of UV irradiated pollination as a practical breeding method.

Keywords: Cowpea; ultra-violet; mutation; germination; survival; vigor

Paper Number: 1430 (Poster Number: 302)

Effect of Three Water Regimes on Micronutrient Concentration (Iron and Zinc) of Biofortified Bean Genotypes Against Malnutrition in South-Kivu Marshy Highlands.

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Faced with climatic change, soil deterioration, technical constraints and demographic outburst, bean production is low and very variable in time and space in South-Kivu. This study focused on the influence of three water regimes on the Iron and Zinc concentration content in four biofortified bean-genotypes for the eradication of malnutrition. Hence, a field experiment was conducted in the Hogola marshy highland during two growing seasons, B2013 and B2014. It took place following a split-plot design. A strategic application of homogenization of the soil fertility of the experimental site by mineral fertilizers type (CaCO₃, KCl and DAP) was conducted. Four biofortified bean-genotypes were the main factor, while water regimes represented the secondary factor, and seasonality, the tertiary factor. Observations focused on Iron and Zinc concentration content in the dry biomass of plants at V3 vegetative stage, in seeds, and soil water regimes. Results show that the cumulative seasonal averages of Iron and Zinc levels in aerial dry biomass drastically decrease from the top to the bottom of the marshy slope, water regimes respectively R3 and R1 according to the seasons and bean-genotypes studied. Thus, in B2013, Iron content reductions were 55.8 and 33.6 against 58 and 32.5 in B2014. Similarly, Zinc content reductions amounted to 31 and 17.8 in B2013 against 33.1 to 16.5 in B2014. Iron and Zinc contents in seeds followed the same trends as those observed in the aerial parts of culture. However, reduction rate of nutrient levels in bean-genotypes varied following this order: HM21-7 > RWK10 > RWR2245 > CODMLB001.

Key words: Marshy highland, Water regime, Micronutrient, Malnutrition, Biofortified bean, South- Kivu.

Paper Number: 1431 (Poster Number: 303)

A Nutritional Profile of Fast Cooking Bean Germplasm.

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Dry beans (*Phaseolus vulgaris* L.) require long cooking times to become palatable. Fast cooking bean varieties offer fuel reduction and time saving value to consumers. There is a need for high throughput non-destructive phenotyping methods so breeders can readily assess the cooking times of their germplasm. The suitability of visible and near-infrared spectroscopy (Vis/NIRS) over the wavelength range of 400–2,498 nm was tested and this method predicted cooking time with accuracies higher than 85.0%. Another important aspect of breeding fast cooking beans is the potential nutritional implications. Fast cooking beans may have intrinsic compositional differences that directly relate to nutrient composition. In addition, the varied time in the cooking process may influence nutrient retention and bioavailability. We determined the nutrient composition and retention of fast, moderate, and slow cooking bean varieties of four different market classes post-harvest and after a year of storage. Intrinsic differences in protein and resistant starch were related to differences in cooking time. Fast cooking bean genotypes also had greater iron and zinc retention and greater iron bioavailability as compared to slower cooking genotypes of the same market class.

Paper Number: 1432 (Poster Number: 304)

Nutritional and Sensory Properties and Consumer Preference of Snack Foods Produced from High Quality Cassava Flour (HQCF) and Legume Blend in Nigeria and Democratic Republic of the Congo.

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Although legumes are oftentimes used as partial substitutes in existing snack foods such as biscuits where the chief ingredient is wheat flour, development of snack foods using legumes combined with High Quality Cassava Flour (HQCF) as a major ingredient is not common. We investigated the nutritional and sensory characteristics and consumer acceptability of a snack food prepared from a composite of cassava and legume flours. A snack food product was produced using High Quality Cassava Flour (HQCF) and full fat soybean flour (50:50) and HQCF and cowpea flour (50:50). The developed products were evaluated for nutritional and anti-nutritional characteristics, sensory evaluation, and consumer acceptability using standard laboratory procedures and sensory tests. Results showed that the snack product fortified with full fat soy flour had significantly higher (over 40% more) protein content compared to the cowpea fortified product. Phytate content was lower in the cowpea fortified product compared to soy fortified product. Boiling soybeans for 10 minutes before processing led to 12% reduction in phytate levels. The sensory evaluation and consumer acceptability results showed cross cultural differences in preference between panellists and among consumers in Nigeria and DRC. Consumers in the DRC preferred the beany taste and aroma of the un-boiled soy variant of the snack food while those in Nigeria preferred the boiled soy variant more. This study demonstrates the potential of improving the nutritional quality of snack foods made from staple food crops such as cassava and also the potential of diversifying use of cassava flour for income generation.

Paper Number: 1433 (Poster Number: 305)

Effect of Processing on Proximate Composition and Sensory Acceptability of Biofortified Bean Flour.

Ulemu Kankwatira, Ulemu Kankwatira, Agnes Mwangwela and Agnes Mwangwela, Lilongwe University of Agriculture and Natural Resources*

The consumption of legumes among young children in rural Malawi remains low due to the preference for maize, leading to high cases of malnutrition. Improvement of the protein quality of foods and the incorporation of legumes to the diet of infants could be the solution. Beans undergo processing before consumption to remove phytohaemagglutinin which is poisonous to humans. The study aimed at evaluating the effect of processing methods on chemical and sensory acceptability of maize and bean flour. Common beans were roasted (75-85°C), fermented (72 hours) and germinated before milling. Porridge from common beans (30%) and maize (70%) blends was evaluated to determine sensory acceptability among 150 mother-child pairs of infants aged 12-36 months. Proximate composition of bean flour samples showed an increase in crude protein content of about 7 to 14%, fat, 18 to 52%, ash, 2%. The high protein content could be useful in addressing the problem of environmental enteropathy which exacerbates malnutrition. There were no significant differences ($p > 0.05$) in product acceptability based on the different processing methods employed among mothers and children. The research outcomes indicate that the traditional processing methods can improve the nutritional quality of maize-beans porridge, improve utilization of beans without affecting overall acceptability of the product. The results provide an opportunity for incorporating legumes in the diet of infants. Observations from this research directly feed into a clinical trial currently underway in Malawi that is utilizing common beans as complementary food to reduce environmental enteropathy and stunting in Malawian children.

Paper Number: 1434 (Poster Number: 306)

Legume Consumption in Malawi: An Overview.

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In Malawi, undernutrition remains a serious public health concern with a 42% prevalence of stunting among under-five children. Two immediate causes of undernutrition are inadequate intake of macronutrients and micronutrients, and repeated illness especially with infectious diseases such as diarrhoea. Malawi has a predominantly agricultural economy, with 85 percent of the population living in rural areas and 51% living below the national poverty line. About sixty percent of households grow maize, 30 percent grow beans and about 35 percent grow groundnuts. The main agricultural export crops are tobacco, tea, sugar, cotton, coffee and groundnuts. Main food crops are maize, Cassava, Sorghum, Sweet potato, rice, beans, bananas and potatoes. Maize is the staple food and is mostly eaten with some vegetables making the typical diet nutritionally poor. Legumes provide a vital supplement to the staple food as they provide vitamins and minerals especially iron and provide a cheap source of vegetable protein that is within means of most rural households. These legumes include common beans, groundnuts, pigeon peas, soybeans, cowpeas, hyacinth bean, Bambara groundnuts, butter bean, green gram and field pea/ garden pea are also grown. Common bean is widely eaten alongside the staple food, by all Malawians in both rural and urban areas, and institutions such as schools, hospitals and prisons, where animal protein is not only scarce but also expensive.

Cowpeas and groundnuts come second as they grow throughout Malawi. Therefore, there is need to study other benefits in relation to infections of including legumes in Malawian diets.

Paper Number: 1435 (Poster Number: 307)

Post-Harvest Curing Practices in the Zambia's Groundnut Chain: Are We Pursuing the Right Battle Against Aflatoxins?.

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Post-harvest practices play a big role in ensuring the quality and safety of groundnuts and groundnut based products traded on the market. Poor post-harvest practices are often associated with aflatoxin contamination of nuts, an issue that is of great concern in the groundnut industry in most African countries. Aflatoxin contamination deprives smallholder farmers an opportunity to access lucrative markets, resulting into loss of household income. This study examined the post-harvest handling practices of groundnuts by the smallholder farmers in Zambia, from the stage when the mature plant is ploughed or hoed out, up to the curing or drying of nuts. The handling practices were examined by means of a thorough empirically based validation at the time of harvest in Chipata and Chibombo districts from which various observations and conclusions are made. The study establishes that pertinent hazardous conditions that are likely to predispose the nuts to aflatoxin contamination exist in the current practices. First, the hoed out mature plants containing the nuts are batched together tightly in a windrow during the curing or drying operation without adequate ventilation. Extremely poor ventilation result into localized heating and moisture accumulation, a condition that is favorable for the growth of *Aspergillus Flavus* and *Aspergillus parasiticus*. Second, nuts with visible fungal infestation are not removed from the mature hoed out plant prior to curing. The infested nuts therefore act as inoculum in the tightly batched structure and infect clean ones during the curing process. Third, the dried nuts are not adequately sorted after curing to separate the infested ones from the clean ones, thereby creating a vicious cycle of infestation in the subsequent storage stage. All these factors impact negatively on the quality and safety of groundnuts. This study, therefore, proposes the use of a raised curing structure with maximum ventilation, made from locally available materials such as bamboos, sorghum or millet stalks. It further suggests for the immediate removal of nuts from the hoed out mature plant prior to drying, and for the immediate sorting in order to remove the infested nuts. The study consistently maintains that there is a window of opportunity for Zambia to reap from the groundnut industry if proper post-harvest practices are adhered to.

Key words: Post-harvest handling, aflatoxin, groundnuts, curing

Paper Number: 1436 (Poster Number: 308)

Phytochemicals Profiles and Antioxidant Activity of Legume Varieties.

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ABSTRACT

Legumes are one of the richest sources of phytochemicals and are used as food and play an important role in the traditional diets in developing countries, especially in Sub-Saharan African countries where they complement the lack of proteins from cereals, roots, and tubers. However, few studies have reported free and bound of total phenolic acids, antioxidant activity, total flavonoids, phenolic acids, antiproliferative activity and cytotoxicity. All the legumes showed a significant amount of total phenolics and differed significantly ($p < 0.05$). Cowpea-Thamagana Speckle (828.69 ± 61.56 mg of gallic acid equiv/100 g of sample, DW) was found to possess the highest free phenolic content followed by Cowpea-Inia 37, Cowpea-Red, Bambara, Groundnut-Mokgalo, Groundnut-Peolwane, Mung bean, Groundnut-Sellie, Bambara Groundnut-Keledi and Tepary Bean. The total flavonoid content ranged from 410.99 ± 21.24 (Cowpea-Thamagana Speckle) to 85.36 mg of catechin equiv/100 g of sample, DW (Tepary Bean). Quantities of chlorogenic, caffeic, ferulic and p-coumaric were either less or not detected in the extracts. Total antioxidant activity was measured using the PSC assay and ranged from 114.6 ± 16.8 (Cowpea-Thamagana Speckle) to 50.7 ± 1.1 mg vitamin C equiv/100g of DW (Tepary Bean). Antiproliferation activities were also studied in vitro using HepG2 human liver-cancer cells, with EC50 ranging from 355.19 ± 4.35 (Cowpea-Red) to 49.36 ± 3.20 mg/mL (Tepary bean). However, no cell cytotoxicity was observed. We demonstrated that legumes and legume varieties are rich in phytochemicals and have high antioxidant and antiproliferation activities. Thus, information on these health beneficiary phytochemical profiles gives an insights to potential application to promote health.

KEYWORDS: Legumes, phytochemicals, phenolics, flavonoids, antioxidant activity, antiproliferation activity

Paper Number: 1437 (Poster Number: 309)

Stability of Yield and Antioxidant Content of Selected Cowpea (*Vigna unguiculata* [L.] Walp.) Mutation Derived Genotypes.

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The suitability of yield and the nutrition status of antioxidant contents (total phenolic and condensed tannin) of cowpea germplasm in the agro ecological zones of Zambia is unknown. This has led to growing of low yielding varieties with low antioxidants, contributing to the increase of health problems i.e. heart attack, hypertension, obesity and cancer. Hence a study was conducted to evaluate the stability of the cowpea yield and antioxidants in the agro ecological zones as well as to determine the relationship of the antioxidants with their seed coat colour. Genotype x Environment (GxE) interaction for grain yield was not present indicating that there was no difference in the response of genotypes in the varying environmental conditions. However, some genotypes had very high yields indicating genotype identification to specific environments. Genotypes MS1/8/1/4 and LT11/3/3/12 were adapted to high potential yielding environment but unstable while BB4/2/4/1 and LT11/5/2/2 were adapted to low yielding and stable. GxE for antioxidants was present and higher yielding genotypes had low antioxidant contents compared to low yielding genotypes. Genotype LT PRT contained higher antioxidant concentration and was stable while MS PRT contained lower concentrations and was unstable. Genotypes with darker seed coat colour contained higher antioxidant concentrations than lighter ones. The study provided an opportunity to identify cowpea genotypes which are stable in yield and antioxidant content and can be grown across the country. Possibilities of breeding genotypes which are high yielding with high antioxidants traits are there to solve the hunger and nutrition challenges faced by the country.

Paper Number: 1438 (Poster Number: 310)

Participatory Preparation and Evaluation of Diversified Bean Based Food Products for Vulnerable Households and Communities in Western Kenya.

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Micronutrient hunger accounts for more than half of the daily infant mortality in sub-Saharan Africa and in Kenya more prevalent among the rural and urban poor. The national bean research programs in East and Central Africa developed bean varieties with high levels of Iron and Zinc. The objective of this study was to, train trainers in preparation and sensory evaluation of nutritious bean products. Three groups from three counties were purposively sampled, NUA1 beans were purchased from Nangina in Busia and other raw materials sourced from local markets and shops. Nutrition education and preparation of raw materials was done, followed by preparation of: Bean Cassava Mandazi, Bean Cassava Chapatti, Bean Sweetpotato Crackies, Bean Sweetpotato Onion Bites, Bean Cassava Cake, Bean Finger millet porridge, Bean Sauce, Beamaves, Bean Sweetpotato mash (Mshenye) and Bean sweetpotato relish. Sensory evaluation using free choice profiling for attributes (acceptability, appearance, taste and flavor) on a hedonic score scale of 1 - 5 was conducted. A total of 95 (74 women and 21men) were trained in (Busia, Vihiga and Siaya), Counties. The most preferred and least preferred products for acceptability, appearance, taste and flavor were Bean Sweetpotato Mash, Beamaves, Bean Sweetpotato Relish, Bean Cassava Chapati, Bean Sweetpotato Crackies, Beamaves, Bean Sweetpotato Crackies and Bean Cassava Chapatti: mean values and coefficient of variation, 4.6, 3.9, 18.36, 4.7, 3.8, 19.31, 4.6, 3.9, 20.29 and 4.6, 3.7, 19.13 respectively. All sensory attributes were insignificantly different (P

Paper Number: 1439 (Poster Number: 311)

Legume Consumption Pattern of Households in Selected Areas of Districts in Malawi.

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ABSTRACT

In Malawi there are efforts on increasing legume production although, little is known on consumption patterns. Understanding of consumption patterns of common beans, soybeans, cowpeas, groundnuts, and Bambara nuts is essential to inform interventions that promote legume consumption among farmers. Legume consumption pattern for 80 legume farmer households in Mzimba and Ntchisi districts of Malawi was studied using a semi-structured questionnaire. The legume production per household was low, ranging from 17kg for cowpeas to 146kg for common beans. Despite low legume production, farmers sold 78.76%, 78.07%, 66.50%, 14.53%, 42.80% and 50.41% of common beans, soybeans, Bambara, cowpeas, groundnuts and garden peas respectively. This affected legume consumption and consequently limiting nutrient intake. Fifty percent of the households consumed 150- 250g/person/day of dry pulses, but only two legumes (soybeans and groundnuts) were consumed four times a week, the rest occasionally. The dry pulses were mostly most consumed as stewed grains, porridge and dhal. Low grain legume production coupled with less legume stocks for consumption and low frequency of legume consumption may limit nutrient intake valuable for human health especially for resource constrained persons. This situation calls the need for nutrition education on legume consumption to smallholder farmers, coupled with a program on reducing selling high proportions of legumes to keep enough for consumption.

Paper/Poster Abstracts

This will increase legume consumption, consequently increasing nutrient intake.

Paper Number: 1440 (Poster Number: 312)

Trade-Off Between Protein Content, Consumer Acceptability and Cooking Time of Released Common Bean Varieties in Swaziland.

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Common beans (*Phaseolus vulgaris*L.) are important legume crop grown by rural smallholder farmers in Swaziland and contribute to household food and income security. Beans are a rich source of protein that are important for human nutrition, however, cooking time (CT) and sensory characteristics greatly influence their acceptability. With increasing cost of fuel, breeders are selecting bean varieties with shorter CT and this could impact negatively on other important consumer attributes such as sensory acceptability. Therefore, understanding the link between CT, protein content (PC) and sensory characteristics is vital for selecting bean cultivars with better consumer acceptability. This study examined the connection between PC, sensory acceptability and CT of six released bean varieties in Swaziland. The beans were pre-soaked for 10 hours and cooked for 60 minutes using a standard recipe. Samples were collected at 30, 45 and 60 minutes intervals for evaluation. The bean samples were evaluated by 27 trained panelists for the degree of doneness (CT) and sensory acceptability on a 5-point hedonic scale and were analysed for protein content using standard methods. The results showed that WERNA bean variety with a short CT and high PC of 26.3% had low overall acceptability of 11.1% compared to RCB265 bean variety with a long CT and low PC of 19.3% which had a high overall acceptability of 33.3%. The study therefore indicates a trade-off between PC, CT and consumer acceptability, suggesting that breeders should consider the main bean attributes in combination rather than taking each attribute in isolation.

Paper Number: 1441 (Poster Number: 313)

Health-Promoting Properties of Underutilized Climate-Friendly African Legumes.

Gyebi Duodu and Amanda Minnaar, University of Pretoria*

There is growing awareness about climate change and its potential effects on food security. A wide variety of legumes (such as cowpeas, Bambara groundnuts and marama beans) that are known to be drought-tolerant and therefore could be regarded as climate-friendly, are also important food sources in Africa. In much of sub-Saharan Africa, rapid urbanization accompanied by poor dietary choices are contributing to growing incidence of diet-related non-communicable diseases such as cancer, cardiovascular disease and diabetes. African legumes are important sources of bioactive compounds such as phenolics which may contribute health-promoting properties. African legumes such as cowpea, Bambara groundnuts and marama beans contain a wide variety of phenolic compounds - mainly phenolic acids, flavonoid-type compounds and proanthocyanidins. Extracts from these legumes display various bioactive properties such as radical scavenging, inhibition of LDL oxidation and DNA damage, prevention of erythrocyte hemolysis and inhibition of starch-hydrolysing enzymes. Taking the looming crisis of the adverse effect of climate change on food security and the growing epidemic of chronic non-communicable diseases into consideration, these underutilized climate-friendly legume crops could be expected to play a pivotal role in combating food insecurity in Africa and combating the scourge of chronic lifestyle diseases.

Paper Number: 1442 (Poster Number: 314)

Human Nutrition and Health.

Joseph Anamuah-Mensah, Center for Learning and Community Development*

HUMAN NUTRITION AND HEALTH

STATEMENT OF THE PROBLEM/HYPOTHESIS

Common Bean has a good nutrition and health benefit for the proper growth of man.

KEY POINT OF THE PROBLEM/HYPOTHESIS

GOOD SOURCE OF ENERGY:

Common beans are about 70% carbohydrate. Starch (43 - 45%), non-starch polysaccharides or fiber (18 - 20%), -galactosides (starchyose, verbascose, and raffinose; 3 - 5%), and sucrose (3 - 5%) are the major types of carbohydrate which is needed for the release of energy needed for working.

DIGESTIBILITY CONSIDERATIONS:

Both bean protein and starch are less well digested than protein and starch from cereal grains. One reason for poorer digestion is due to the physical form of the protein and starch when it enters the stomach and small intestine. The digestibility of bean protein is rather low compared to animal protein and most cereal grains. True protein digestibility averages about 73%, but digestibility range from 65 – 85% depending upon seed coat color. Digestibility of protein from white and light colored beans is in the 80 – 85% range while protein digestibility for black, dark brown and dark red varieties ranges from 65 – 75%.

SIGNIFICANCE OF THE OVERALL FINDING ON COMMON BEAN AND FUTURE RESEARCH

Common bean has a very good nutritional content for the healthy living of human. It would be very advisable if common being is being cultivated much in our various countries in the future in order for us not to depend too much on animal protein but rather use common being as our source of protein and nutritional food.

Paper Number: 1443 (Poster Number: 315)

Effects of the Legumes, Common Beans and Cowpeas, on Child Development and Morbidity Caused, Versus a 10% Soy Based Food.

*Yankho Kaimila**, College of Medicine

Effects of the legumes, Common beans and cowpeas, on child development and morbidity caused, versus a 10% soy based food Y. Kaimila¹; K. Maleta¹; I. Trehan²; C. Thakwalakwa¹; M. MAnary²; K. Stephenson²; S. Agapova² ¹School of Public Health and Family Medicine, College of Medicine, University of Malawi, Blantyre, Malawi. ²Department of Pediatrics, Washington University School of Medicine, St Louis, Missouri, USA. Background The first 3 years of life predispose children to high levels of infection and malnutrition due to transition from exclusive breastfeeding to complementary food. In sub-Saharan African communities, maize, cassava and sorghum dominate the diet; these starches are micronutrients and protein poor. Environmental enteric dysfunction (EED), which is an inflammatory syndrome increases during this period which leads to a leaky gut, frequent infections, growth faltering, and stunted development. New evidence has emerged suggesting a potential role of legumes (beans and cowpeas) in reversing the consequences of EED in animal and early human studies. Objective [0] To determine effect of bean or cowpea based complementary foods on dietary intakes, clinical morbidity and growth and development when provided at 20-40g per day for 6-12 months in rural Malawian children. Methods 2 cohorts of healthy 6 month old and 12 month old children will be given 20-40g of either common bean flour, cowpea flour or the control corn soy blend for 6 and 12 months respectively. Outcomes assessed include dietary intakes using 24 hour recalls, EED using lactulose: mannitol assessments, growth using change in height for age Z scores, disease morbidity using a questionnaire and development using a questionnaire. Progress Data on the trial profile, baseline characteristics and the first dietary assessment of the study participants as at 6 months will be presented.

Paper Number: 1444 (Poster Number: 316)

Effects of Phosphorus and Soil Moisture on Grain Yield, Leaf and Grain Tissue Concentration of Iron and Zinc in Three Bean (*Phaseolus vulgaris* L.) Genotypes.

*Harrison Munuve** and *Simon Nguluu*, South Eastern Kenya University

Common bean (*Phaseolus vulgaris* L.) is an important source of protein, minerals and food for the majority of the poor population in sub-Saharan Africa. However, its contribution to grain yield and micronutrient level is constrained by moisture stress and low available soil phosphorus. A study was carried out to determine the effects of bean genotypes, P fertilizer and moisture regimes on bean (*P. vulgaris* L.) grain yield and tissue concentration of Zn and Fe in three bean genotypes. The results of grain yield showed highly significant ($P = 0.0006$) interaction between moisture regimes, genotypes and P application rates. Grain yield of the three genotypes increased with P application rate up to 60 kg ha⁻¹ regardless of the moisture regimes. The leaf and grain concentration of Fe and Zn showed highly significant ($P < 0.01$) interaction between moisture regimes, genotypes and P fertilizer application rate. A significant ($n = 90$; $r = -0.34860$; $P = 0.0008$) negative correlation between the grain yield and leaf Fe concentration and highly significant ($n = 90$; $r = -0.58292$ $P = 0.0001$) negative correlation between grain yield and leaf Zn concentration were observed. Hence an increase in grain yield correlates with a decrease in leaf concentration of Fe and Zn. In order to increase the grain yield and grain concentration of Fe and Zn, application of P fertilizer, maintaining adequate soil moisture and planting superior bean genotype is required. Key Words: Phosphorus; Soil Moisture; Yields; Bean; Iron; Zinc.

Paper Number: 1445 (Poster Number: 317)

The Antimicrobial and Antioxidant Potential of Bambara Groundnut Seeds and Related Value Added Products.

*Joseline Felix-Minnaar**, Afkile Kamana, Siyasanga Zantsi, Fanie Rautenbach, Marilize LeRoes-Hill and Victoria Adaora Jideani, Cape Peninsula University of Technology

Indigenous knowledge (IK) indicates that eating home preparations of Bambara groundnut (BGN) has excellent health benefits. To date, no scientific evidence could support this claim. Antimicrobial and antioxidant activity of BGN could indicate a link with the IK. Antimicrobial and antioxidant activity accrued to food products typically are associated with the raw material and is often lost through processing. This study investigated the antioxidant and antimicrobial activity, of extracts from whole BGN(WBGN) and hulled BGN(HBGN) and related value-added products- milk (WBGNM & HBGNM) and yoghurt (WBGNY & HBGNY). Significant differences exist in antimicrobial activity of the extracts. Extracts show high activity against *A.niger* and *S.cerevisiae*, intermediate against *S.aureus* and least against *E.coli*. Antimicrobial activity is in the order WBGN > WBGNM > WBGNY and within the hulled samples HBGN > HBGNM > HBGNY. Total phenolic content (321.01-97.31 mg/L) and Oxygen Radical Absorbance Capacity (ORAC) {3798-2313 mmole Trolox/mL} activity varied significantly among the milk and yoghurt made from whole and hulled seeds. In all cases BGNM showed higher phenolic content and antioxidant activity than BGN; and whole seed products higher activity than hulled seed products. This indicates that BGN and its products possess antimicrobial and antioxidant activity. BGN is cultivated as mainly a subsistence crop in many areas of the African continent. The knowledge of antimicrobial and antioxidant activity of BGN and its products as reported in this work confirms the IK associated with BGN. Hence BGN and its products could contribute to food and nutrition security for Africa.

Paper Number: 1446 (Poster Number: 318)

Effects of Aflatoxin Exposure and Legume Based Complementary Foods on Child Nutritional Status.

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Statement of the problem: In spite of the negative health effects of aflatoxins exposure, the aflatoxins problem in Malawi has often been considered primarily within the trade barrier context and not the public health context (Monyo et al, 2010). In addition, there is no complementary food that has been formulated which is low in aflatoxins but has high nutrient density and improves the nutritional status of children. This study formulated maize-pigeon pea-groundnuts-finger millet blended complementary food which has low aflatoxin levels and has high nutrient density and improves nutritional status of children.

Key findings:

The study revealed that aflatoxin levels in maize-pigeon pea-groundnuts-finger millet blend ranged from 0-2.5ppb with the mean of 0.16±0.44. Nutritional status of children fed maize-pigeon pea-groundnut-finger millet blend improved with evidence from the increase in body weight with a mean of 9.1Kgs±1.35 at baseline to 10.2Kgs±1.37 after 21 days of feeding trial while control group children who ate usual porridge weight reduced from 9.0Kgs±1.3 at baseline to 8.8Kgs±1.1 after 21 days. Maize-pigeon pea-groundnut-finger millet blended complementary food had high nutrient density due to the combination of the different legumes and cereals. Overall significance of the findings to grain legumes and possibly future research and/or development activities: Study findings are essential in developing nutrition education messages that promote consumption of the maize-pigeon pea-groundnut-finger millet blend which reduces exposure to aflatoxin, improves nutrient intake and nutritional status among children. Future research should be conducted to find out whether maize-pigeon pea- groundnuts- finger miller blend can improve child growth.

Paper Number: 1447 (Poster Number: 319)

Linking Agriculture to Nutrition: The Role of Nutrition Education in Bean Seed System Development in Southern Africa.

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Undernutrition continues to be a major concern for most Southern African (SA) countries, more so in rural farming communities compared to urban areas. Nutrition sensitive agriculture that incorporates nutrition promotion and education building on existing knowledge, is one of the key programming principles for improving nutrition along the food production-to-consumption pathway. Efforts towards this strategy are often limited by shortages of seed of nutritious food crops, including legumes. This paper seeks to share the results of using a previously untested nutrition education strategy to disseminate bean varieties in Malawi, Mozambique and Zambia. Nutrition education coupled with training on diverse ways of preparing bean-based dishes using the food basket approach to enrich existing dishes was conducted resulting in participatory documentation of recipes with farmers, local caterers and extension personnel.

Paper/Poster Abstracts

In response to increased local demand for bean grain, farmers were trained in seed production through context-based community schemes, giving rise to three main lessons. Small scale farmers demonstrated capacity to build from small start-up volumes of seed (Malawi), to produce seed that meets quality assurance standards (Mozambique) and to establish local catering businesses with bean-based dishes. In Zambia, the inclusion of bean dishes under a multi-sectorial approach to nutrition (Scaling up nutrition initiative) further unlocked the demand for bean varieties. Incorporating nutrition education in seed system development demonstrated potential to stimulate demand for quality seed of improved bean varieties among farming rural households.

Key words: nutrition education, seed system, agriculture-nutrition pathway

Paper Number: 1448 (Poster Number: 320)

Consumer Acceptance for Biofortified Iron Beans in Rural Communities. Evidence from Africa and Latino America.

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Micronutrient malnutrition is a public health problem in many developing countries affecting two billion people worldwide. To breed and deliver staple crops with high micronutrient content or biofortification could reduce micronutrient deficiencies. Its success depends on whether biofortified foods are accepted and consumed by target populations. This paper gathers evidence of consumer acceptance for high iron bean varieties in Guatemala and Rwanda, countries with one of the highest prevalence of iron deficiency and beans consumption in Latin-American and Africa respectively. Using the Becker-DeGroot-Marshak mechanism, the paper investigates the willingness to pay for the iron varieties in comparison with a traditional one, and the effect of nutrition information and the frequency of providing the information on consumer WTP. In Rwanda consumers are willing to pay a large premium for the Red Iron Bean variety, but not for the White Iron bean variety, relative to the local variety in the absence of nutritional information. Nutrition information and its repetition significantly increases consumer demand for the WIB variety. In Guatemala, although the average WTP for the iron bean variety is marginally higher in the presence of information and its repetition, there is no significant difference between the consumers WTP between the varieties evaluated. Consumers value both varieties, iron and traditional, equally and the presence of information and the frequency in which this information was received didn't have any impact on consumers' preferences. These findings could inform the design of efficient delivery and marketing strategies for iron bean varieties in both countries.

Paper Number: 1449 (Poster Number: 321)

Breeding Second Generation Biofortified Bean Varieties for Africa.

Paul Macharia Kimani and Ahmed O Warsame, University of Nairobi*

Micronutrient malnutrition is one of the most serious health challenges facing vast sectors of Africa's population particularly resource-poor women and children. Development and utilization of drought tolerant, biofortified varieties is regarded as probably the most effective, sustainable and potentially long-lasting strategy for reducing micronutrient deficiencies and coping with frequent droughts. Our objective was to develop second generation biofortified bean lines combining drought tolerance, multiple disease resistance and higher grain iron and zinc concentration than the first generation varieties currently grown by farmers in east, central, southern and west Africa. Forty-seven F2 populations segregating for mineral density, resistance to biotic and abiotic stress factors, marketable grain types and yield potential were developed at Kabete Field Station, and advanced to F4 as population bulks. F4.5 progenies were evaluated under drought stress and no-stress conditions. Selected drought tolerant families were evaluated for disease resistance and agronomic traits at Kabete and Thika from 2011. Results showed highly significant (P

Paper Number: 1450 (Poster Number: 322)

Nutritional Enhancement of Common Bean: Status of Seed Mineral Concentrations and Strategic Targets for Crop Improvement.

Michael A Grusak, Phillip N. Miklas and Karen A. Cichy, USDA-ARS*

The health and well-being of humans depends on a safe, nutritious, and adequate food supply, with many of these foods coming from pulse crops. Common bean is an important food source that can provide several nutrients, including a range of minerals to humans. We have been interested in improving several quality and production traits in Andean bean lines with a focus on the development of new cultivars for deployment in Sub-Saharan Africa. In this study, seed and pod wall mineral concentrations were assessed in 144 lines of the 396 member Andean Diversity Panel (ADP). The lines were grown in replicated field trials in Prosser, WA under drought and non-stress conditions. In addition, we analyzed whole-plant mineral partitioning in a group of bean lines to understand the temporal and spatial distribution of minerals in different tissues throughout crop development.

Paper/Poster Abstracts

We will present ranges of mineral concentrations and discuss the importance of observed mineral allocations between pod walls and seeds, as well as mineral distribution at the whole plant level. Single-nucleotide polymorphism trait associations, determined for several minerals using association mapping, also will be presented. Finally, we will use these data to discuss strategies for increasing mineral levels in seeds of common bean and will provide an analysis of the extent to which these enhancements are achievable in light of current or modified source tissue pool sizes. This work was funded by USDA-ARS (Agreement 58-6250-0-008) and by USAID (Feed the Future Grain Legumes Project).

Paper Number: 1451 (Poster Number: 323)

The Effect of Processing on the Antinutrients in Selected Legumes in Botswana.

Olekile Tibe, Boipuso Legwatagwata and K Motlogelwa, Botswana College of Agriculture*

Edible legumes are important sources of protein in many developing countries. However, this protein may not be available for digestion because of antinutritional factors. Two local varieties of cowpeas were obtained from the Botswana Agricultural Marketing Board in Gaborone, Botswana. Processed and unprocessed samples of *Tylosema esculentum* (marama) and the two local cowpea varieties *Vigna unguiculata* (tswana and black-eyed) were analysed for condensed tannins and trypsin inhibitors. The marama beans were roasted in an oven at 80 °C for 30 minutes, and the cowpeas were boiled for one hour. Condensed tannin was measured using the butanol-HCl method. For the condensed tannin contents, the results (%) for the unprocessed samples were: marama 0.381, black-eyed 0.111 and tswana 0.381 respectively. After processing, the condensed tannin results (%) were: marama 0.223, black-eyed 0.050 and tswana 0.032. The trypsin inhibitor activity was determined using benzoyl-DL-arginine-p-nitranilide hydrochloride method. The trypsin inhibitor activities (TIU/g dry matter) for the raw legumes were: marama 27.8, black-eyed 17.4, and tswana 17.3. After roasting of the marama bean and boiling of the cowpeas, the following results were obtained: marama 26.4, black eye 8.4 and tswana 8.0. The results showed that processing reduced the antinutrients in the legumes studied by varying amounts. In order to benefit from the high protein contents in these legumes, they have to be well cooked in order to reduce or completely destroy the antinutrients.

Paper Number: 1452 (Poster Number: 324)

Nutritional Composition of Pulse Legume Crops and the Impact of Leaf Removal on Yield.

Rosemary Bulyaba, Iowa State University*

The role of legumes worldwide includes food, nutrition and income generation among others. Legumes such as cowpea can thrive in adverse environments like drought, making them a climate smart technology for hunger mitigation. Although total protein intake per capita from pulses exceeds 10% in several countries, the potential for legume leaf utilization for protein and other nutrients has not been widely considered and, insufficient information is available on leaf removal effects on pulses, yield and leaf nutritional composition. A two-year experiment was conducted in central Iowa, USA to determine the effects of leaf removal rate on nutritive value of removed leaf tissue and subsequent grain yield of cowpea (*Vigna unguiculata*), lablab (*Lablab purpureus*) and soybean (*Glycine max*). Dry leaf mean nutrient concentration was 229, 17832, 4461, 21991, 3702, 113, 205, 86 mg kg⁻¹ for crude protein, Ca, Mg, K, P, Mn, Fe and Zn. Unlike 2013, leaf removal rate affected yield and some yield components in 2014. Additionally, in 2014, pulses with 0% leaf removal had 20, 32, and 35% more yield and seeds weighed 6, 11 and 12% more than those with 33, 66 and 99% leaf removal. Aboveground biomass, yield and yield components also differed amongst crops in both years. Pulse leaf utilization as vegetables or forage may improve human and ruminant nutrition by using leaves that would otherwise be left in the field. Pulse leaves are an excellent micro-nutrient supplement to high-carbohydrate diets especially in developing countries and are also a good crude protein source for livestock.

Paper Number: 1453 (Poster Number: 325)

Pre-Processing Techniques, Cooking and Nutritional Properties of Common Beans Grown in Kenya with Regard to Storage Conditions and the Hard-to-Cook Defect.

Valentine Wacu Kamau, Elizabeth Namaemba Wafula, Peter Kahenya Kinyanjui, Daniel Njoroge Mwangi, Anselimo Makokha and Daniel Ndaka Sila, Jomo Kenyatta University of Agriculture and Technology*

Common beans (*Phaseolus vulgaris*) are highly nutritious and widely consumed in Kenya. The tropical climatic conditions of temperature (25 °C) and relative humidity (> 65%) exposes beans to the development of the hard-to-cook defect (HTC) during storage. This leads to high energy consumption during cooking. Furthermore, it also impacts negatively on texture and nutritional quality. Among the common bean varieties, there are some that are relatively easy-to-cook (ETC). But it is not known whether storage conditions affect the HTC and ETC beans in the same way. Use of pre-processing technologies in beans preparation remains largely unexplored. Soaking of beans in water prior to cooking is the common pre-processing practice done to shorten the cooking time. However there are limited documented studies on the effect of using different soaking solutions on the cooking and nutritional properties of the HTC and ETC beans.

Paper/Poster Abstracts

Six month storage under tropical conditions caused development of the HTC defect in both Rose coco and Red kidney common bean varieties. Cooking profiles revealed that Rose coco takes a shorter time to cook than Red kidney. The soaking pre-treatment in sodium carbonate shortened the cooking time significantly ($p < 0.05$) in both. For nutritional analysis in both varieties; crude protein content did not have significant ($p < 0.05$) change while significant ($p < 0.05$) differences were observed for moisture, ash, protein digestibility, phytates, tannins and mineral content. Further research should look into developing HTC defect resistant strains and other pre-processing techniques that shorten the cooking time.

Paper Number: 1454 (Poster Number: 326)

The Marriage of Nutrition Education and Bean Production Leads to Nutrition-Sensitive Agriculture in Masfrijol.

Celina Wille, Sharon Hoerr and Carolina Molina, Feed the Future Legume Innovation Lab at Michigan State University*

Traditionally, agricultural extension workers and health professionals have addressed malnutrition independently—rarely across disciplines. Consequently, among Guatemala's indigenous populations, childhood malnutrition has continued unabated for decades, despite numerous efforts by well-intentioned organizations promoting better agriculture or diets. This cycle illustrates how increased food production does not necessarily reduce malnutrition. Nutritionally beneficial foods are either not available or affordable or, when available, not readily consumed by those who need them. The MASFRIJOL project in Guatemala's western highlands has two objectives: increasing bean productivity and enhancing dietary nutrition among rural Mayan families according to World Health Organization Food-Based Recommendations of promoting nutrient-dense local foods over supplements. To meet these objectives, MASFRIJOL agricultural and health professionals are cross-trained on both improving maternal and child nutrition and increasing bean production in Guatemala's western highlands. Specifically, they provide, theoretically and practically, family-focused education on both increasing bean production and enhancing nutrition through bean consumption. Using mobile vans designed to reach remote communities, these dual-purpose extension teams disseminate improved black bean varieties and teach local farmers improved agricultural practices to help increase bean yields two- to five-fold. Concurrently, they teach these farm families the value of eating beans for nutritional health along with delicious ways to prepare them to ensure their consistent consumption across age levels. This marriage of agricultural extension and nutrition education has provided an innovative model for practically promoting dietary diversity in the diet of Guatemala's indigenous peoples. The project's success offers hope for similar communities throughout the world.

Paper Number: 1455 (Poster Number: 327)

Effect of Soy Fortification on Proximate Composition of Cassava Based Porridges.

Everlyne Namtala Sikuku, University of Eldoret, Serrem, C. A., & Imo, B.*

Protein Energy Malnutrition is a public health challenge in developing countries. Children below five years are the most commonly affected, predisposing them to serious developmental challenges that may eventually reduce their performance. In Busia county cassava is grown and consumed in form of ugali and porridge either singly or mixed with millet, maize or sorghum. Cassava is nutrient deficient while soy is nutrient dense though not utilized in the diets due to ignorance of its nutritional value and lack of skills for its preparation. The aim of the study was to investigate the effect of soy fortification on the proximate and acceptability of cassava cereal porridges from Busia County. Proximate analysis was done for moisture, crude protein, crude fat, ash and carbohydrates using the AOAC Internationally approved methods while a consumer panel was used to test acceptability of the cassava cereal soy fortified porridges. The proximate analysis results showed a significant increase in the protein, mineral and lipids content of the plain and composited products by 89.11%, 71.43% and 66.67% at 30% fortification while at 50%, 95.05% 88.88% and 79.04%, respectively. All millet based ugali variations ranging from plain, composited to the fortified had higher proximate values for ash, fat and protein. Consumer panelists preferred the soy fortified porridges which were darker in colour especially cassava millet soy 30%, 50% and cassava soy 50%. In conclusion, porridges and ugali fortified at 30% were found to provide 50% of the daily protein requirements per 100 g for children aged 1-3 years. The soy fortified porridges were found acceptable by the consumer panelists therefore can be used for supplementary feeding in schools to alleviate PEM as well as household consumption in Busia county or any other population.

Key words: PEM, children, cassava composites soy fortification

Paper Number: 1456 (Poster Number: 328)

Degradation of Azadirachtin a on Treated Cowpea with Azadirachta indica Seed Oil and Its Persistence on Callosobruchus Maculatus.

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The cowpea beetle *Callosobruchus maculatus* is considered in many tropical countries as major pests of legumes. *Azadirachta indica* seed oil has long been used for the control of *C. maculatus*. Azadirachtin A is the main compound known for its insecticidal properties. For a better protection of cowpea by using neem seed oil, it is important to determine the degradation of Azadirachtin A coupled with the persistence of neem seed oil to cause adult mortality and to inhibit progeny production. The degradation of Azadirachtin A in treated seed was determined between 0 and 180 days. Results on the degradation on Azadirachtin A contained in *A. indica* oil on treated cowpea showed that the active ingredient decreased with ascending storage intervals ranging from 0 – 180 days, irrespective of the dose level. At the 180 days storage interval and with the lowest dose of 2 ml/kg roughly 0.10 mg/kg of Azadirachtin A remained on the treated cowpea. Neem oil caused a significant day-dependent mortality of the insects and its effectiveness decreased with time. There was 100% mortality of *C. maculatus* (5 ml/kg) after treatment but 180 days after treatment, for all dosages, less than 10% mortality recorded. With 3 ml/kg, neem oil strongly inhibited the progeny production (100 %) of *C. maculatus* up to 180 days. Since neem seed oil taste bitter, they may be recommended more for long term grains storage (≥ 6 months), during which the bitter taste may reduce as the Azadirachtin level would drop to close to zero.

Paper Number: 1457 (Poster Number: 329)

Quantification of Yield Loss Caused By the Groundnut Leaf Miner (*Aproaerema modicella* Deventer) on Different Soybean Genotypes in Uganda.

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Although soybean acreage has continuously increased overtime in Uganda, a number of important biotic and abiotic constraints have remained a threat to its production, leading to a decline both in seed yield and quality. Among the serious pests is the groundnut leaf miner (GLM), *Aproaerema modicella* (Lepidoptera: Gelechiidae), originally confined to groundnut. *A. modicella* is an oligphagous pest of other leguminous host plants such as pigeon pea (*Cajanus cajan*). This pest is proving to be a great risk to continued production of the soybean crop by the small-scale farmers. As such, a study was done in eastern Uganda to quantify the yield losses caused by the groundnut leaf miner (*Aproaerema modicella* Deventer), on soybean in Uganda. Six commercial varieties (Maksoy 1N, 2N, 3N, 4N, 5N and Namsoy 4M) were planted in two locations in two rounds in 2013B in a split plot RCBD. Two treatments (protected and unprotected) made the main plots and varieties as the sub-plots. Results indicated that soybean yields and marginal returns from the pesticide protected plots were higher than those from the unprotected plots with yield losses from 37.3 to 65.7% recorded in the unprotected plots. This study provides confirmation that *A.modicella* poses a substantial threat to crop productivity and should be considered a priority in pest management. Strategies for effective management and control are pertinent to avoid total crop loss or even evolving and spreading of this pest to other important leguminous crops such as common bean (*Phaseolus vulgaris*), and cowpea (*Vigna unguiculata*), which may act as potential hosts with time.

Paper Number: 1458 (Poster Number: 330)

Belowground Influence of Rhizobium Inoculant and Water Hyacinth Composts on Yellow Bean Infested By *Aphis fabae* and *Colletotrichum Lindemuthianum* Under Field Conditions.

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The application of water hyacinth compost and a commercial *Rhizobium* inoculant had some positive effects on performance of the commercial Rosecoco bean cultivar, depending on the water hyacinth compost formulation. However, farmers in the Lake Victoria region mostly rely on local bean cultivars, among them the yellow bean 'Mugasa' that is commonly grown in western Kenya. Unlike commercial bean cultivars, the yellow bean is among local cultivars that are yet to be studied, especially in terms of *Rhizobium* nodulation and pest infestations under the influence of soil fertility amendments such as water hyacinth compost. The objective of this study was to determine the influence of *Rhizobium* inoculant and water hyacinth composts on the performance of yellow bean in terms of growth and yields, and how these applications affect natural infestation of the plants by *A. fabae* and *C. lindemuthianum*.

Rhizobium inoculant and water hyacinth composts increased root nodulation by 200 % - 524 %. Aphis fabae population was high by 230 % on Rhizobium-inoculated plants grown with H+EM. Incidence of C. lindemuthianum was high in Rhizobium-inoculated plants. Plant growth and yields were not different between fertility and Rhizobium treatments despite pest infestations. Plants grown with DAP had very few nodules, reduced germination percentage, slow growth and low yields. The water hyacinth composts and Rhizobium inoculant contain microbes whose belowground benefits on the yellow bean include, improved root nodulation necessary for nitrogen fixation, and tolerance to aboveground infestations by A. fabae and C. lindemuthianum.

Paper Number: 1459 (Poster Number: 331)

Evaluation De L'efficacite De Cinq Biopesticides Contre LES Populations De Thrips De Maruca Vitrata EN Culture De Niebe (VIGNA UNGUICULATA (L.) Walp.).

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Résumé : De nos jours, l'utilisation des insecticides chimiques contre les insectes ravageurs du niébé, *Vigna unguiculata*, en culture est décriée pour leur nocivité sur la santé humaine, animale et environnementale. L'existence de pesticides naturels comme alternatives aux insecticides chimiques capable de réduire les dégâts des insectes ravageurs en culture est une réalité. Cependant, l'un des défis majeur reste leur identification. C'est dans ce contexte que la présente étude a été entreprise pour évaluer cinq biopesticides et identifier le plus efficace contre les populations de thrips et de *Maruca vitrata*, principaux insectes ravageurs du niébé en culture au Burkina Faso. Six traitements en cinq répétitions incluant un témoin sans insecticide, un témoin de référence constitué deltaméthrine et Chlorpyrifos-éthyle, des combinaisons de l'huile de neem + MaviMNPV ; des extraits de feuilles de neem + extraits de feuilles de papayer ; de l'huile de neem + extraits de *Cleome viscosa* et du MaviMNPV seul ont été appliqués à partir du 40^e jour après semis. L'application des biopesticides s'est poursuivie une fois par semaine jusqu'à la maturation, tandis qu'une seule application de l'insecticide chimique est intervenue quinze jours après la première. Les résultats obtenus montrent que l'application de l'huile de neem + MaviMNPV réduit le taux d'attaque des fleurs et des gousses entraînant une augmentation significative des rendements en graines, comparée aux témoins. Dans la perspective de gestion intégrée des insectes ravageurs, ce biopesticide pourrait constituer une solution alternative intéressante pour les petits producteurs.

Mots clés : biopesticides, MaviMNPV, thrips, *Maruca vitrata*, niébé

Paper Number: 1460 (Poster Number: 332)

IPM-Omics: From Genomics to Extension for Integrated Pest Management of Cowpea.

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Insect pests often develop resistance to insecticides, and such resistance represents a serious management problem. Devising methods that concurrently delay resistance and minimize insect injury to crops has long been a goal of integrated pest management (IPM). Unfortunately, successful application of IPM has remained a challenge. To be able to overcome these challenges, we developed a comprehensive tool set by combining traditional field studies with genomic tools, an emerging field which we refer to as "IPM-omics". We developed and applied a set of microsatellite markers for the estimation of genetic variability among *Maruca vitrata* populations in six West African countries, and on four different host plants of *M. vitrata*. We also applied Roche 454 sequencing technology to detect polymorphisms in the different populations of four other pests of cowpea across West Africa - *Megalurothrips sjostedti*, *Aphis craccivora*, *Clavigralla tomentosicollis* and *Anoplocnemis curvipes*. Results obtained from these studies allowed a much clearer idea of the genetic variability in these pest populations across West Africa. It also identified putative single nucleotide polymorphisms (SNPs), which can be used for characterizing the populations of the different insect pests, and also identified candidate genes putatively involved in insecticide resistance, regulation of insect growth, and response to disease transmission. Overall the findings from these studies are effective in making well-informed decisions about the best control measure(s) against these insect pests by first deciding when and where the insect pests occur, and then developing and deploying the most cost-effective and environmentally benign strategies for controlling these pests.

Paper Number: 1461 (Poster Number: 333)

Resistance to Insect PEST Complex in Elite Lines in Pigeonpea (*Cajanus cajan* L.) in Dry Areas of Kenya.

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RESISTANCE TO INSECT PEST COMPLEX IN ELITE LINES IN PIGEONPEA (*Cajanus cajan* L.) IN DRY AREAS OF KENYA

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ABSTRACT

Pigeon pea (*Cajanus cajan* L.) is an important legume crop in semi-arid tropics, although its yield potential has not been fully realized due to biotic and abiotic stresses that limit its production. Insect pest complex of pod borer (*Helicoverpa armigera*), sucking bug (*Clavigralla tomentosicollis*) and pod fly (*Melanagromyza cholcosoma*) may cause up to 100% yield loss. This study evaluated resistance to insect pest complex in advanced elite and breeding lines in dry parts of Kenya. The study was carried out in three sites (Kenya Agricultural Livestock Research Organization- Marigat, Agricultural Training Centre-Koibatek and Fluorspar-Chepsirei) in 2014 growing season. Sixteen ICRISAT elite genotypes were evaluated in randomized complete block design (RCBD) in 3 reps. Results showed significant ($P \leq 0.05$) differences in grain yield performance, incidence and severity across sites. The damage was more severe in Marigat amongst all insects (pod borer -37.2%), sucking bug (39.3%) and pod fly (5.9%) than in ATC- Koibatek (pod borer-1.9%, sucking bug-8.4% and pod fly-5.9%) and Fluorspar (pod borer-3.6%, sucking bug-6.8% and pod fly-2.9%). Genotypes ICEAPs 00850, 00902, 01541 and 1154-2 showed higher levels of resistance to the insect pest complex and high yields. Grain yield was negatively correlated with pod borer and sucking bug damage and non-significance with pod fly damage. There is need for further studies to validate these findings and identify mechanisms of resistance to different insect pests to understand the effect of each insect. IPM control methods also need to be determined and recommended.

Key words: Pigeonpea, insect pest complex, resistance, yield potential, yield loss.

Paper Number: 1462 (Poster Number: 334)

Evaluation De Quelques Paramètres Biologiques Et De L'efficacité De *Therophilus Javanus* Bhat Et Gupta (Hymenoptera : Braconidae), Parasitoïde Larvaire De *Maruca Vitrata* Fabricius (Lepidoptera : Crambidae), Foreuse Des Fleurs Et Des Gousses Du Niébé (*Vigna*

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La culture du niébé est sujette à de nombreux dégâts dont les plus importants sont dus à l'attaque des ravageurs notamment le foreur des gousses, *Maruca vitrata*. Cette étude s'inscrit dans un contexte de contrôle biologique et a mis en évidence la biologie et l'efficacité de *Therophilus javanus*, un potentiel ennemi naturel, récemment importé de Taiwan. Sous une humidité relative moyenne de $54,45 \pm 1,99\%$ et une température moyenne de $26,75 \pm 0,27^\circ\text{C}$ au laboratoire entomologique de la section Niébé de IITA-Bénin, nous avons, après avoir testé l'effet des âges larvaires sur le parasitisme de l'insecte, étudié l'influence des substrats nutritifs naturel et artificiel sur quelques paramètres biologiques du parasitoïde et de l'hôte. Il en ressort que le parasitoïde pique avec succès les larves de 24h et 48h, mais les proportions de femelles suivant ces deux âges sont respectivement 7,45% et 41,78%. La longévité de la femelle accouplée, son taux de parasitisme, sa fécondité, et le sexe ratio sont respectivement $7,67 \pm 0,45$ jours; $37,07 \pm 1,66\%$; $10,76 \pm 0,59$ nymphes/jour et 39,19% sous régime naturel puis $11,2 \pm 0,87$ jours; $20,74 \pm 4,58\%$; $6,22 \pm 1,37$ nymphes/jour et 35,81% sous celui artificiel de l'hôte. L'âge larvaire et le substrat nutritif de *M. vitrata* ont significativement influencé les paramètres biologiques de *T. javanus*. Nous recommandons par ailleurs de tester ce parasitoïde sur les organismes non ciblés.

Mots clés : *Therophilus javanus*, *Maruca vitrata*, paramètres biologiques, régime alimentaire, niébé.

Paper Number: 1463 (Poster Number: 335)

Yield and Yield Related Component of Cowpea As Affected By Cultivar, Planting Date and Spraying Regime.

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Abstract

Cowpea is attacked by a wide spectrum of insect pests that ravages the crop in the field at different growing stages sometimes resulting into complete crop failure. In order to reduce insect pest damage, increase cowpea grain yield and other yield related components, an experiment was conducted using five improved cowpea cultivars with varying maturity dates and one local check, two planting dates (June and September) and two spraying regimes (sprayed and no sprayed) across two major agro-ecological zones during 2012 and 2013 cropping seasons. The experiment was laid out in a randomized complete block design with three replications at three locations Sumbuya, Serabu and Nguala. The measured parameters were grain yield, pod load, biomass, days to 50% flowering and days to maturity. Result showed that the effect of cultivar, planting date and spraying regime on the measured parameters were highly significant. Also interaction effect of cultivar, planting date and spraying regime on the measured parameters were all significant. Grain yield, pod load and biomass were higher in sprayed plots compared to unsprayed plots. Also, grain yield and pod load were higher when planting was done in September. Furthermore, all the improved varieties out yielded the local variety. Days to 50% flowering and maturity was shorter for all the improved varieties compared to the local variety with spraying plots flowering and maturing earlier when planting was done in September compared to June. This results shows that integrating cowpea cultivar with date of planting alongside minimal application of insecticide can lead to the reduction in cowpea insect pests across the major agro-ecological zones of Sierra Leone thus, resulting into increase in grain yield and other yield related components of cowpea.

Key words: Planting date, Grain yield, Pod load, cultivar, spraying regime

Paper Number: 1464 (Poster Number: 336)

Mixed Infections of Multiple Pests and Diseases Are the Norm on Common Beans Grown on Smallholder Farms in Western Kenya.

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Western Kenya is considered to be the major food basket of Kenya. Common beans in this densely populated region is highly regarded by the small scale farmers as a source of income and food particularly for its richness in dietary proteins, calories and fibre. However, pest and disease infections reduce yields of the crop to less than 0.5t/ha in the region. Most of the pests and diseases have been well researched and some have been targeted regionally by breeding programs. But, most of the studies entirely focused on single pests and diseases yet multiple infections on common beans have been frequently observed and not well documented. Co-infection has been shown to exacerbate disease prevalence, transmission and damage in many cultivated crops. This paper focused on establishing the prevalence of pest and disease infections on common beans in Western Kenya. A total of 512 farms in 3 agro ecological zone regrouped on the basis of altitude were surveyed for visual symptoms and presence of pests and diseases during the short and long rains of 2013. Our findings revealed that over 50% farms had more than one pest and disease infection in a field. The most prevalent pests were foliage beetles, leaf hoppers and aphids while diseases were Common bacterial blight, Angular leaf spot, and Virus complex. Irrespective of agro-ecology and season, multiple infections were common in the surveyed fields. Currently, the potential use of mixed cropping and clean seeds to reduce the occurrence of the pests and diseases is being explored.

Paper Number: 1465 (Poster Number: 337)

Integration of Piper Guineense Essential Oil with Cowpea Varietal Resistance in Control of Cowpea Seed Beetle, *Callosobruchus Maculatus* Fabricius.

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Pesticide abuse causes a great menace in postharvest handling of grain legumes. In an attempt to reduce the risks associated with pesticide abuse and ensure leguminous food security, an experiment was conducted to evaluate the potentials of combining Piper guineense essential oil (PgEO) with cowpea varietal resistance in the control of cowpea seed bruchid, *Callosobruchus maculatus* Fabricius.

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Cowpea varieties (Sokoto, Drum, Oloyin and Gwallam) available to Nigerian resource-poor farmers were used. There was interactive effect of cowpea cultivar and PgEO dose for some studied parameters. On seeds without PgEO, the numbers of eggs on Sokoto (5.06) and Drum (4.99) were significantly (p

Paper Number: 1466 (Poster Number: 338)

Evaluation of Insecticide Application for Managing Bean Flower Thrips and Pod Borers on Common Bean in Uganda.

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Insect pests are a key constraint to common bean production in Uganda. There is, however, limited information to guide farmers on the use of insecticides. We therefore investigated spray regimes of cypermethrin for managing flower thrips (*Megarurothrips sjostedtii*) and pod borers (*Maruca vitrata*) on the common bean variety, NABE 4, at the National Crops Resources Research Institute. The treatments comprised: spraying throughout, spraying starting at the beginning of flowering and podding stages, and an untreated control, laid out in a randomized complete block design with four replicates. Cypermethrin sprays reduced flower thrips infestation by between 55 – 72%. In 2013B, thrips infestation was similar between treatments. In 2014A and B, thrips were higher in plots sprayed starting at podding compared with other treatments and the control plot. Spraying throughout resulted in the highest reduction in pod borer damage compared with other treatments. In 2014B, plots treated with cypermethrin out-yielded the untreated plots by 228 – 333 Kgs/ha. In 2013B, plots treated beginning at podding had the greatest yield advantage (107 Kg/ha), whilst in 2014A, plots sprayed throughout out-yielded the untreated plots by 415 Kg/ha. There was negative correlation between grain yield and the number of thrips (-4.41 to -0.58) and pod borer damage (-0.21 to -0.99). Cypermethrin sprays are effective and lead to increased yields. We recommended need-based application of insecticides based on thresholds for the different beans pests. We also recommend evaluating other insecticides for effectiveness and profitability.

Paper Number: 1467 (Poster Number: 339)

Propriétés Répulsives Des Extraits De *Cleome Viscosa* L. (Capparaceae) En Situation De Non Choix Contre *Clavigralla Tomentosicollis* (Hemiptera : Coreidae), Punaise Suceuse Des Gousses De Niébé En Conditions De Laboratoire.

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Au Burkina Faso, la production du niébé pourrait être plus importante si les principales contraintes à la production sont levées. Cette légumineuse subit en champs les attaques d'un cortège d'insectes ravageurs parmi lequel la punaise suceuse de gousse, *Clavigralla tomentosicollis* occupe une place significative. Les pertes de rendement dues à ce ravageur peuvent représenter 60 à 100% en l'absence d'une mesure de protection. Pour contrôler ce ravageur, les agriculteurs utilisent des insecticides à large spectre qui sont toxiques pour l'environnement et le consommateur. Cette étude qui s'inscrit dans la quête d'une méthode alternative, vise à évaluer l'effet répulsif des extraits aqueux de *Cleome viscosa* L. (Capparaceae) contre la punaise suceuse de gousse en situation de non choix. Trois doses (Pure, 0.75% et 0.50%) d'extrait aqueux ont été utilisées pour traiter des bouquets composés de gousses fraîches et des feuilles et déposés dans les cages en présence de 10 femelles de *C. tomentosicollis*. Un témoin non traité a été constitué. Les observations ont été effectuées pendant 24 h à intervalle de temps de 2 h. Douze heures après le début du test, le pourcentage de répulsion était dose dépendante avec un taux de répulsion variant entre 35 et 75%. A partir de 14 h, L'effet répulsif a chuté pour toutes les doses mais celui de 0.75% de matière active de *C. viscosa* est significativement plus élevé et ce jusqu'à la fin des observations. Au bout de 48 heures, l'activité de ponte de *C. tomentosicollis* a été significativement réduite (P

Paper Number: 1468 (Poster Number: 340)

Combined Activity of *Maruca Vitrata* Multi-Nucleopolyhedrovirus, Mavimnpv, and Oil from Neem, *Azadirachta indica* Juss and *Jatropha curcas* L., for the Control of Cowpea Pests.

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The insecticidal activity of *Maruca vitrata* (F.) multi-nucleopolyhedrovirus (MaviMNPV) combined with oil from neem, *Azadirachta indica* Juss and *Jatropha curcas* L. (Euphorbiaceae) was studied under laboratory and field conditions against three key insect pests of cowpea, *Vigna unguiculata* (L.) Walp.

Second instar *Aphis craccivora* Koch and *Megalurothrips sjostedti* Trybom nymphs, and third-instar *M. vitrata* larvae, all from laboratory colonies, were treated with various concentrations of one of the control agents separately or combined. Daily mortality was recorded for five days (*A. craccivora* and *M. sjostedti* nymphs) or fourteen days (*M. vitrata*) and the larval and pupal development as well as adult emergence were assessed. Combination of MaviMNPV resulted in a significantly higher larval mortality in *M. vitrata* than treatment with either virus or botanical insecticide alone at the corresponding concentrations. Larvae of *M. vitrata* infected with MaviMNPV and treated with botanical oils died sooner than those infected with only one control agent. Combinations of MaviMNPV and botanical oils produced additive or synergistic effects. No evidence of antagonistic effects was noted. In field experiments, the application of botanical insecticide and MaviMNPV either alone or in combination was effective in reducing insect abundance over the four weeks, and preventing yield loss. In the first field season, where the *M. vitrata* population was higher, the combination of the virus and either of the botanical pesticides induced significantly higher yields than spraying chemical insecticide. Application of MaviMNPV in combination with *J. curcas* and *A. indica* oil has proven to induce consistent MaviMNPV infection in *M. vitrata* populations. The combined application of MaviMNPV and botanical oils is discussed in the context of integrated pest management.

Paper Number: 1469 (Poster Number: 341)

Effect of Eucariptus and Commercial Vegetable Oils Against Dry Bean Damage By Bean Bruchids.

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This study evaluates the efficacy of locally extracted eucalyptus oil in controlling bean beetles (bruchids), and compares it with commercial vegetable oil and actellic. Bean bruchids, notably *Acanthoscelides* sp are among the most important bean storage pests most often controlled using chemical pesticides eg actellic, despite the substances being expensive and hazardous, hence the need for development of cheaper and safer control methods. Test treatments were applied to lots of 50g of dry beans, each infested with 10 pairs of *Acanthoscelides obtectus* and puncturing and emerging bruchid adults determined. Eucariptus oil, applied direct (coating of beans with oil) and indirect (placing oil in cotton wool wrapped in net-bag), applied at different dosages (0.5 ml, 0.25 ml and 0.1 ml/50gm seed) and vegetable oil were tested alongside actellic and untreated seeds. Effect of treatments when bruchids, were introduced at 0, 10, 20, 30, 40, 50 and 60 days and treatments applied similarly after 10 days intervals was also evaluated. Eucalyptus oil had (100%) bruchids suppression at all levels of concentration followed by vegetable oil (83%) as compared to control. There was no significant difference ($p > 0.05$) for reduced bruchid puncturing between vegetable oil and control and between eucalyptus oil and actellic (95%). Eucalyptus oil at 0.5 ml/50g had the longest active live (over 40 days) and inhibited bruchid (60% inhibition) when applied ever 20 days after infestation. Being a natural product and this effective, eucariptus oil can be recommended as a safer alternative. However further tests should be carried out to determine its effect on physiological and/or genetical factors of bean seeds.

KEYWORDS: *Acanthoscelides obtectus*; Efficacy; Eucalyptus oil; Commercial vegetable oil;

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Paper Number: 1470 (Poster Number: 342)

Effect of Biopesticide for Controlling *Maruca .vitrata* Population on Cowpea Crop in Niger.

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It was assessed different biopesticides, virus MaviNPV, Neem seeds aqueous extract, virus Mavi NPV +Neem seeds aqueous extract, Neem oil, control treatment and conventional pesticide Capt 88 EC on *M.vitrata* population at CERRA Maradi Station. Two improved cowpeas varieties IT90K372-1-2 and IT99K573-1-1 were used for the experiment during two consecutive cropping seasons 2014 and 2015. Significant difference was observed between the treatments. Neem seeds extract and when it is combined with NPV virus were effective considerably for controlling *M.vitrata* population with the two varieties. A cowpea yield increase of 69.46% and 43.50% were recorded compare to farmer habitual yield respectively for IT90K372-1-2 and IT99K573-1-1 variety. This study show that biopesticide has proven effective in protecting cowpea pods against *M.vitrata* attacks and can be used in the Sahel to reduced pest damage on crops.

Key words: cowpea, variety, *M.vitrata*, biopesticides, Neem seeds, Virus MaviNPV, yield

Paper Number: 1471 (Poster Number: 343)

Bruchid (*Callosobruchus maculatus*) Tolerance Assessment of Ten Bruchid Resistant Cowpea (*Vigna unguiculata*) Varieties.

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Abstract

The resistance of cowpea to bruchid infestation has been a major concern to plant breeders as some improve cowpea varieties become susceptible to the polymorphic nature of this insect pest. Ten resistant varieties were collected and screened for bruchid resistance to Cowpea genotypes. Comparative data evaluated from the study indicated that seed coat does not influence bruchid resistance in cowpea seeds. Results showed seed size to be positively correlated with percentage adult emergence of the insect pest. Mean development period for successful adult emergence ranged from 30-46 days. Susceptibility index indicates that majority of the varieties studied were moderately resistant to the bruchid infestation with TVu 11953 being the most resistant of all with index value of 1.78. Analysis of seed coat resistance indicated that antibiosis, not antixenosis is responsible for seed bruchid resistance in cowpea with no significant difference observed in oviposition preference.

Keywords: Cowpea, Resistance, infestation, Bruchid.

Paper Number: 1472 (Poster Number: 344)

Insecticide Spray Regime Effect on Cowpea Yield and Financial Returns in Northern Ghana.

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Cowpea (*Vigna unguiculata* L Walp) is the second most important legume in Ghana next to groundnut. Insect pests are the most important hurdles to cowpea production in Ghana causing 80-100% yield loss. While several management strategies are available, insecticides are the most effective. Farmers use insecticides, but they spray once in most of the cases which is not enough to control insect pests. Field trials were conducted in 2013, 2014, and 2015 production seasons in three communities of Northern Ghana in order to assess the effect of higher spray regime on yield and net financial returns. The treatments were arranged in split-plot design with 2 spray regimes (one spray and three sprays) in the main plots and 6 cowpea varieties (Sangotra, Apagbaala, Padituya, IT 99K 573-1-1, Zaayura, and farmers' local variety) in the sub plots. Results indicate that spraying cowpeas three times have positive and significant effects on grain yield and financial net return as compared to spraying them only once. Grain yield increases by about 45% as a result of increasing the frequency of application while the net financial return increases by nearly 90%. The first degree stochastic dominance analysis also shows that the higher spray regime is always dominant over the lower spray regime. This implies that applying insecticides three times on cowpea not only increases grain yield and net returns but also reduces the probability of getting lower yields and financial returns which makes it suitable to smallholder farmers who are usually risk averse.

Paper Number: 1473 (Poster Number: 345)

Improved Tolerance to Bruchids *Callosobruchus Maculatus* in Common Bean *Phaseolus vulgaris* through Induced Mutation.

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Bean production in Zambia is faced with several constraints including low yielding varieties, abiotic and biotic stresses. Crop production ranging from 200 to 800 kg/ha are common against a potential of 3000 to 4000 kg/ha. The bean beetle *Callosobruchus maculatus* (Coleoptera: Bruchidae) is responsible for the largest post-harvest losses in storage. Use of non-synthetic chemical options such as host-plant resistance for the control of *C. maculatus* is strongly encouraged. Induced mutation provides an alternative method of creating genetic variation and affects a wide range of plant characteristics such as morphological, biological and biochemical ones. Therefore, the aim of this study was to generate resistance to bruchids in common beans using induced mutation and to test its heritability. Bean seeds from each of the 18 mutant lines were screened in the laboratory for resistance to *C. maculatus*. Results showed that among the mutant lines, CA38-38-9-B and RB 608 were tolerant to bruchids. The susceptibility index to bruchid attack was 0.000 for CA38-38-9-B as compared to parental lines which was 0.027, indicating high tolerance to bruchid.

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Furthermore, CA38-38-9-B and RAB 608 showed very low levels of bruchid emergence, further supporting the high tolerance of these genotypes to bruchid attack. When these tolerant lines were used as parents to introgress bruchid tolerance in farmer preferred varieties, the progeny of CA38-38-9-B were also tolerant to bruchids indicating heritability of tolerance. When RAB 608 was crossed with the same farmer preferred varieties, their progeny was moderately tolerant. This study also provided evidence for the presence of multi resistance factors including seed coat thickness and chemical constituents (methyl esters). This study demonstrated that bruchid resistant bean varieties could be developed through induced mutation. However, a further study on chemical composition and consumer preference is proposed.

Paper Number: 1474 (Poster Number: 346)

Incidence and Severity of Fusarium Wilt of Bambara Nut (*Vigna subterranea*) in Western Kenya.

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Paper Number: 1475 (Poster Number: 347)

***Pseudomonas syringae* pv. *syringae* (Pss) causes bacterial brown spot (BBS) on dry bean (*Phaseolus vulgaris* L.) in many parts of the world including South Africa. The inheritance to BBS resistance in dry beans is unknown.**

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Selected international bean accessions at the Agricultural Research Council of South Africa were used to conduct an inheritance study to determine the number of genes conditioning BBS resistance. Crosses between BBS resistant sources Hystyle and BBSR 17 and susceptible local cultivars Kranskop-HR 1, Sederberg and Teebus-RCR 2 were made. Parents, F1 and F2 progenies were planted in a greenhouse and F3 in a field. Trials were planted in 5 m rows with 750 mm inter-row and 75 mm intra-row spacings and arranged in complete randomised block design. Trials were inoculated at the fourth trifoliolate stage with a Pss suspension adjusted to 1x10⁸ CFU ml⁻¹, and disease was rated at 7, 14 and 22 days after inoculation using the modified 1-9 CIAT scale. Data were subjected to analysis of variance and Chi square analysis. Disease severity data were used to determine heritability. All F1 plants were resistant to BBS, the F2 populations showed 3:1 (resistant:susceptible) segregation pattern, and the F3 families showed a 1:2:1 segregation ratio, indicating the presence of a single dominant gene in each of the donor parents. This suggests that resistance may be easily overcome and that it is essential to identify more BBS resistance genes.

Paper Number: 1476 (Poster Number: 348)

A Strategy to Manage Highly Variable Pathogens of Common Bean in Africa and the Americas.

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Rust, anthracnose (ANT), and angular leaf spot (ALS), are widespread and devastating diseases of common bean (*Phaseolus vulgaris*) in Africa and the Americas. Host resistance is the most cost-effective strategy to manage these fungal pathogens. However, achieving effective resistance is difficult due to extensive virulence diversity of all three pathogens. Hundreds of virulent strains (races) have been reported for each pathogen. Moreover, there are many reports of the occurrence of new virulent races that overcome the resistance of previously resistant varieties. Varieties with single genes have usually been the most affected by these occurrences. We are proposing here an effective gene pyramiding strategy that combines several disease resistance genes. This strategy is based on the current knowledge of the virulence diversity of the pathogens and of the reaction of the disease resistance genes to a broad diversity of all three pathogens. It is also based on the current knowledge of the origin, evolution, and diversity of the common bean. This strategy uses phenotypic and DNA markers and genomic technologies to develop common bean lines combining effective Andean and Mesoamerican genes that confer broad and durable resistance to the rust, ANT and ALS pathogens of Africa and Latin America. Previous results using this strategy to manage rust have resulted in common bean lines with resistance to all known races of the rust pathogen. Here we propose to use the latest research information to expand the gene pyramiding strategy to include broad resistance to ANT and ALS.

Paper Number: 1477 (Poster Number: 349)

Virulence of *Macrophomina Phaseolina* Isolates in Common Bean (*Phaseolus vulgaris*) Genotypes.

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Charcoal rot caused by *Macrophomina phaseolina* (Tassi) Goid, is an important disease in common beans (*Phaseolus vulgaris*) in the dry and warmer areas of Puerto Rico and in much of the tropics and subtropics worldwide. The virulence of three isolates from Isabela (Mph-ISA-TARS), Juana Diaz (Mph-JD) and Aguadilla (Mph-13) and the reaction to Mph-JD of different common bean genotypes were determined. The pathogen was multiplied in pasteurized rice for 15 days in the dark at room temperature. The inoculum consisted of 3 grams of rice colonized by *Macrophomina phaseolina* deposited around the seedlings of six different genotypes. Seven and 21 days after inoculation, the plants were evaluated using the CIAT scale (1-9): 1= no visible disease symptoms and 9 = approximately 50% or more of the hypocotyl and stem tissues covered with lesions and pycnidia. In a separate experiment, isolate Mph-JD was used to inoculate four common bean lines, including BAT 477 used as the resistant and G122 as a susceptible checks. Results showed that virulence varied among the three isolates and the genotypes evaluated differed in their response to the pathogen depending on the isolate. The most virulent isolate was Mph-JD isolate when compared to the isolates from Isabela and Aguadilla. In two consecutive trials, 'Mecosta' (ADP-225) was the most susceptible line and G122 (susceptible check) showed moderate resistance and this reaction was dependent on the isolate inoculated. TARS-MST1 was the most resistant to Mph-ISA-TARS. Consistently, 'Mecosta' and 'Zawadi' (ADP-106) were susceptible to all 3 isolates and the lesion length was significantly longer than in BAT 477 and G122. Genotypes BAT 477, TARS-LFR1, TARS-MST1 and G122 were similar in disease severity and lesion length at 21 days after inoculation. These results indicated that differences exist in virulence of *Macrophomina phaseolina*.

Paper Number: 1478 (Poster Number: 350)

Angular LEAF SPOT Disease Status and Characterization of the Causative Pathogen (*P. GRISEOLA*) in Tanzania.

*Luseko Amos Chilagane**, *SOKOINE UNIVERSITY OF AGRICULTURE*, *Susan Nchimbi*, *Sokoine University of Agriculture* and *Tim Porch*, *USDA-ARS*

Angular leaf spot caused by the fungus *Pseudocercospora griseola* is one of the most important disease of common bean in Tanzania. Breeding for resistance to this disease is complicated by the variability nature of the pathogen. In Tanzania no thorough attempt has been done to check the variability of this pathogen which limits proper strategies for breeding for durable resistance. This work aims at evaluating ALS disease status and elucidating the variability of the causative pathogen in the country. A survey was conducted in two bean growing seasons 2013 and 2014 in nine main bean growing regions of Tanzania for disease severity study and disease sample collection. Isolation was done and DNA was extracted for molecular characterization where sequencing was done for ITS region and ACTIN gene. The results indicated the presence of the disease in all the regions where Kagera and Mbeya had the highest severity (score of 7) while Rukwa and Manyara had the lowest (score of 4). Phylogenetic analysis depicts the presence of Andean and Mesoamerican groups of *P. griseola* and further most of the Mesoamerican isolates were from Kagera region where 60% of all the isolates collected from this region were Mesoamerican and few from Arusha (50%) and Tanga (33%). All other regions presented only Andean isolates. This knowledge on variability and distribution of the pathogen is very crucial in planning for breeding. More work is under way on pathogenecity testing.

Paper Number: 1479 (Poster Number: 351)

Phenotypic Characterization of Bean Rust Isolates from Common Bean in the Guatemalan Highlands.

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Beans are an inexpensive source of quality protein, fiber, and iron for Guatemalan's poorest households. The daily per capita bean consumption is approximately 64 grams. Unfortunately, bean productivity is affected by abiotic and biotic stresses. Among the biotic factors bean rust (*Uromyces appendiculatus*) is problematic due to its abundant diversity for virulence. When bean rust infection occurs early, farmers can have up to 100% yield losses. The objectives of this project were to characterize the bean rust races present in 12 bean producing locations in Guatemala, and to identify potential resistance genes. The methodology conducted was under field conditions by using mobile nurseries with the new standard of 12 differential lines with known rust resistance genes. Disease reaction was determined using a 1-6 grading scale, and 12 races were found (13-0, 4-63, 4-39, 3-4, 4-63, 4-55, 16-63, 22-61, 5-47, 4-39, 4-55 and 4-62). The Andean differentials showed resistance at most locations tested. However, the Mesoamerican Ur-3+ gene caused resistance in half of the locations, and Ur-CNC in five of 12 locations. This is important because undesirable stunting is caused by transferring Andean genes to Mesoamerican varieties. Therefore, ICTA's breeding program will include parents with Ur-3+ and Ur-CNC, and design a crossing plan including bridge varieties in order to introduce Andean genes without undesirable effects.

Paper Number: 1480 (Poster Number: 352)

Report of *Sclerotinia sclerotiorum* As the Causal Organism of the Leaf Spot and Stem Blight Disease of African Yam Bean (*Sphenostylis stenocarpa*).

Akinbiyi Andrew Akinlabi and Iyabo Kemi Kehinde, Federal University of Agriculture, Abeokuta*

Objectives/ Problem statement: There has been a dearth of information on the fungal field diseases, which affect the production of African yam bean (*Sphenostylis stenocarpa*) in Nigeria. This study was therefore carried out to assess the fungal field pathogens including *Sclerotinia sclerotiorum* associated with the crop. Methodology and Results: Seed varieties used in the study were obtained from the Institute of Agricultural Research and Training, Ibadan and International Institute of Tropical Agriculture, Ibadan. Ten seed varieties were planted using a Completely Randomised Block Design in five replicates. Disease assessment was carried out weekly between April and September 2013. The leaves, pods and stems were assessed for disease symptoms and taken to the laboratory for pathogen isolation. The healthy and diseased specimens were cut into small pieces of 3mm diameter and disinfected in 5% Sodium Hypochlorite (NaOCl). Pathogenicity of the organism was done using foliar spray method on a 7 days old AYB plant. (Dinghra and Sinclair, 1985). There was the presence of white cottony mycelia on leaves close to the base of the plant on field as well as round black sclerotia on the leaves and plates in the laboratory. Using the appropriate morphological guides as illustrated in Barneth and Hunter (2010), the organism was identified as *Sclerotinia sclerotiorum*. Significance of findings: The pathogenicity test confirmed the organism as the causal factor of leaf spots and stem blight of AYB. The organism has previously been reported on some members of the Fabaceae family; however, this probably is its first report of pathogenic invasion of African yam bean. The soil used for planting could be considered a possible medium of disease transmission since *S. sclerotiorum* is known as a soil organism. This study has shown that AYB is susceptible to *S. sclerotiorum*.

Paper Number: 1481 (Poster Number: 353)

Low Cost Management of the Variable Pathogen Causing Bean Rust in Africa and the Americas.

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The fungal pathogen, *Uromyces appendiculatus*, causing the bean rust disease only infects *Phaseolus vulgaris* spp, including dry and snap beans. The high virulence diversity of over 100 races of the rust pathogen, survival by the sexual recombination stage, and fungal spores that travel long distances makes this pathogen a consistent problem for beans. Although fungicides can reduce yield losses, chemicals/application equipment increase cost of production, especially for small landholders. Deployment of rust resistance genes can manage the disease while not adding any bean production costs. Selecting rust resistant bean lines can be done in field trials under natural infection. However, only resistance to the race(s) in that location and year would be known. More informed resistance gene selection would result from collecting the rust spores, increasing them in a screenhouse on a susceptible bean, and inoculating bean lines with specific rust resistance gene(s). All that is needed is experience in plant pathology, a mist chamber and screenhouse located away from infected bean fields. We have found that rust resistance genes of Mesoamerican origin tend to be resistant to Andean rust races while genes of Andean origin are resistant to Mesoamerican rust races. A mobile nursery of 12 bean rust resistance lines with genes of Mesoamerican and Andean origin can be placed in a rust infected field for 2-3 hours then misted overnight and rated for rust. This is a simple, inexpensive method to identify lines with effective resistance. These lines would then be introgressed with landraces/cultivars or advanced breeding lines.

Paper Number: 1482 (Poster Number: 354)

Reaction of the Base 120 Lines to Angular Leaf Spot in Puerto Rico.

*Tim Porch*1, Diego Rodriguez1, Timothy Porch2 and James S Beaver1, (1)University of Puerto Rico, (2)USDA-ARS*

Common bean (*Phaseolus vulgaris* L.) is limited by diseases such as Angular leaf spot (ALS), caused by *Phaeoisariopsis griseola* (Sacc.) Ferraris sin. *Pseudocercospora griseola* (Sacc.) Crous & U. Braun. The virulence of *Phaeoisariopsis griseola* isolate ALS-9029-JD2 from Juana Diaz, PR was determined by inoculating 76 bean lines of the BASE 120 trial and susceptible controls in two different screenhouse trials during June-July (Juana Diaz) and October (Mayagüez), 2015. Five plants of each line were spray inoculated (1×10^5 conidia ml⁻¹) two weeks after emergence. In the first experiment a sprinkler maintained high relative humidity (51/96%, average min./max.). Daily average temperatures registered were 24/34 °C (min./max.). Twenty one days after inoculation disease severity was evaluated using the CIAT 1-9 scale. Resistant genotypes were considered as those with disease severity scores below 3 and no synnemata emerging after 24 hours of incubation of the leaves under humid chamber conditions. Ten genotypes were resistant, 17 were moderately resistant and the remaining 51 genotypes were susceptible to the isolate ALS-9029-JD2. In the second trial of the 76 lines, nine genotypes showed resistance. These results are in agreement with the results from the trial conducted in Juana Diaz. SCAR markers SH13 and SNO2 were used to correlate the presence of the Phg-1 and Phg-2 genes with the phenotypic response of the genotypes inoculated with isolate ALS-9029-JD2.

Paper Number: 1483 (Poster Number: 355)

Summary of the Bean Diseases Regional Trials Planted at Mount Makulu in 2014/2015 in Zambia.

*Mathias Tembo**, *Kennedy Muimui* and *Patrick Chiza Chikoti*, *Zambia Agriculture Research Institute*

Diseases are the major factor limiting bean productivity in Zambia where it is a major staple plant protein food in the local diet. Most of the bean varieties grown in Zambia are susceptible to the major bean diseases. The results of the 2014-2015 bean diseases regional trials are summarized. A table with data on the incidence and severity of common bacterial blight (CBB) and angular leaf spot (ALS) are included. The program aims at increasing bean yields and quality, specifically through incorporating disease resistance especially CBB and ALS. An experiment using a randomized complete block design (RCBD) was conducted at Mount Makulu Research Station, Lusaka, Zambia to evaluate 49 bean types from the national breeding programme for resistance to CBB and ALS. The disease severities and incidences were recorded. Differences between treatments were highly significant with 12 bean types showing high resistance to CBB and ALS. Symptoms of other diseases such as anthracnose, leaf rust and bean common mosaic virus (BCMV) are presented. The bean yields showed wide variability and adaptability among the bean types evaluated. Breeding for disease resistance to identify sources of resistance and evaluation of the bean varieties responses to diseases is recommended. Further recommendations should advance the development of laboratory disease protocols as an aid to the generation of diagnostic tools that can serve to speed up the management of diseases in farmers' fields.

Keywords: Bean diseases; incidence; severity; bean yield; Zambia

Paper Number: 1484 (Poster Number: 356)

Occurrence of Cowpea Scab Disease (*Sphaceloma* sp.) in Uganda.

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Cowpea (*Vigna unguiculata* L. Walp) is the third most important legume food crop in Uganda. The mean yield is less than 400 kg ha⁻¹. Scab (*Sphaceloma* sp.) disease is one of the major constraints of cowpea production in the country, capable of causing yield losses of up to 100%. Cowpea scab is the anamorph of *Elsinoe phaseoli* in common bean (bean scab). A study was conducted in the country to determine the incidence, severity and distribution of scab disease in some major cowpea growing districts across three agro-ecological zones over a two year period. The disease was found to be wide spread in all the districts with mean incidence ranging between 35-70% and mean severity 2-4. Both incidence (71%) and severities (3.2) were found to be higher in fields previously cropped with either a legume crop or cassava than fields previously cropped with other crops (incidence = 64%; severity = 3.1). Also, scab disease incidence and severities were both higher in intercropped fields than the levels recorded in fields which practiced sole cropping. The study also showed that scab had high incidence and severity across districts in Uganda suggesting the need to develop resistant cultivars. This indicates the need to establish the variability of the pathogen to inform the breeding programme for development of resistant varieties.

Paper Number: 1486 (Poster Number: 358)

Survey of Cowpea Viral Disease Symptoms and Detection of Associated Viruses in Selected Cowpea Growing Areas in Ghana.

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Abstract Cowpea (*Vigna unguiculata*) plants showing mosaic, and other virus-like symptoms, were noticed during the 2014 growing season in fields located at Mampong, Ejura-Sekyeredumasi, Nkoranza (Humid forest zones) and Amantin-Atebubu (Derived savannah zone) in the Ashanti and Brong Ahafo regions of Ghana. A survey was conducted in 2014/2015 spanning one hundred locations within the four locations. Incidence and severity of some virus symptoms as well as farmers perception on virus diseases in the surveyed areas were obtained with the aid of survey sheets and questionnaires. Symptomatic leaf and mature seed samples were collected from each location for virus identification in the laboratory. Seed and Aphid transmission tests, Mechanical sap transmission, ACP-ELISA and RT-PCR were used for virus detection. The survey revealed that farmers cultivate virus-infected seeds season by season, thus causing high incidence and severity of viral diseases. High incidence and severity of virus diseases was observed in the Ejura-Sekyeredumasi district where most farmers in the other districts obtain seeds for cultivation. Mosaic and mottling were the commonest symptoms observed. Other symptoms included leaf puckering, necrosis, deformation and death of the entire plant which was least observed among the symptoms. The highest incidence (81.6%) and mean severity (3.01) values of virus symptoms was observed in Ejura. Percent incidences (72.5% and 70.7%) and severities (2.72 and 2.74) recorded in Atebubu and Mampong respectively were not significantly different (P

Paper Number: 1487 (Poster Number: 359)

Aphid Resistance and Biomass Production of Erect Cowpea Genotypes in Uganda.

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Erect types of cowpea (*Vigna unguiculata*) allow high plant densities, but there is limited information on the effect of plant type on aphid damage and biomass production in Uganda. Changing climatic conditions (increased dry periods) contributes to increase damage from cowpea aphids, reducing plant vigour and biomass, thereby reducing yield of grain and of edible leaves. A previous trial indicated wide agronomic variability among our collection of erect types, with an overall advantage of erect types in yield and early harvest compared to spreading types. Fifty four cowpea genotypes were characterized for aphid reactions and biomass production at Makerere University Agricultural Research Institute-Kabanyolo in 2015B (Sept-Dec). Although there was moderate to strong correlation among the growth parameters, a weak relationship was observed with aphid intensity. Aphids Infestation was low on 20% of the genotypes (infestation < 30%) while 37% showed high susceptibility (incidence 52 – 74%). Eight genotypes (14%) had both low severity and incidence of aphids. No leaf damage was detected on 35% of the genotypes while 11% showed distinct susceptibility (severity score ≥ 3). The range of scores concentrated in the intermediate range, producing a non-significant result for incidence and severity among genotypes on the omnibus F-test. Further data collection and testing will confirm whether the genotypes with minimal damage provide stable resistance and high biomass production in multiple environments. The opportunity for marker-assisted selection of specific traits using candidate markers will be assessed, along with the possibility of genomic selection based on a selection index.

Paper Number: 1488 (Poster Number: 360)

Genetic Diversity of Kenyan Cowpea and Response of the Cultivars to Cowpea Aphid Borne Mosaic Virus (CABMV).

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Choice of Program Topical Category for Paper: 2

Preference of Oral or Poster Session: Oral presentation

ABSTRACT

Cowpea (*Vigna unguiculata*) is one of the important food legumes cultivated commercially in the tropics and sub-tropics. Cowpea makes a significant contribution to human food and livestock fodder. The dual purpose has made the crop very attractive particularly in areas where land is scarce. However, the most important constraint to cowpea production is attributed to the predominance and persistence of virus diseases particularly, cowpea aphid-borne mosaic virus (CABMV). CABMV is one of the most economically significant virus to cowpea due to devastating effects in all the cowpea growing regions. This study investigated the genetic diversity of Kenyan cowpea and reaction of selected cultivars to cowpea aphid-borne mosaic virus. The study characterised about 25 cultivars available in Kenya using 12 SSR markers. Seeds of the various cultivars were planted at field conditions at the University of Nairobi. DNA was then extracted from the young leaves harvested on the second trifoliolate. The extracted DNA was quantified using Bio spectrophotometer by measuring the optical density at an absorbance ratio. PCR process was carried out using SSR markers known for cowpea and used to screen 25 cowpea DNA samples. To determine the DNA integrity as well as the functionality, the DNA was subjected to horizontal electrophoresis on 2% agarose gel. PCR reaction products were analysed on KBPLUS 6.5 denaturing polyacrylamide gel; the DNA profiles scanned were scanned. Data were scored with 1 and 0 used to represent band presence while an absence of bands will be scored with the value 0. A dendrogram was developed for the 25 cultivars. The 25 cultivars were again grown in house and infected the CABMV at the second trifoliolate leaf stage and their reaction to the virus observed for one month to determine resistant and susceptible cultivars. AMOVA (Analysis of Mol. Var.) was used to determine genetic distance analyses. Subsequently, SSR markers linked to CABMV resistance in the cowpea cultivars were determined with regards to susceptibility and resistance observed in the study.

Paper Number: 1489 (Poster Number: 361)

Developing a Screening Protocol for *Sclerotium Rolfsii* Sacc. Pathogenic on Common Beans: Determination of Optimal Inoculum Levels.

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Abstract

Southern blight caused by *Sclerotium rolfsii* Sacc. is an important disease of common beans (*Phaseolus vulgaris* L.). Yield losses may reach 100% under suitable environments for disease development. There is no known resistance in common bean germplasm currently available, thus the need to identify sources of resistance to the disease. To achieve the above, a reliable screening protocol is needed. We investigated the effect of varying soil inoculum on seed germination and southern blight disease incidence and severity in the greenhouse. Using a highly pathogenic isolate, bean lines MLB49-89A, NABE15, K132, ALBs 3 and 5 and RWR719, were planted in trays inoculated with 100, 50, 25, 10 and 5g of inoculum /20 kg of pre sterilized soil. Non-inoculated trays acted as controls. Data was collected on seed germination, southern blight incidence and severity (scale of 1-5). Percentage seed germination was significantly influenced by inoculum level. Control seeds registered 100% germination, while seeds treated with 100g inoculum/20Kg soil registered 8.5% germination. Similarly, the highest southern blight incidence and severity were recorded for seeds treated with 100g inoculum/20Kg soil. It was interesting to observe that even at the lowest inoculum level (5g/20Kg soil), considerable disease developed (incidence and severity of 82.7% and 3.4, respectively). There was a strong negative correlation between inoculum level and seed germination; and a positive one between inoculum level, and incidence and severity of Southern blight. The findings of our study will greatly help bean researchers in choosing an appropriate inoculum level in designing screening trials against *Sclerotium rolfsii*.

Paper Number: 1490 (Poster Number: 362)

Bean Diseases in Southern Highlands of Tanzania: Current Occurrence Status and Management Options.

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Common beans (*Phaseolus vulgaris*L.) rank first among the grain legume crops grown in Tanzania and are grown in all districts of the Southern highlands. Diseases are among the principle factors limiting common bean production in Tanzania and estimated yield losses of up to 100% have been reported. Infected seeds are the main sources of primary inoculums from which disease outbreaks detrimental to yield loss and grain qualities in farmer's fields emerge and transported from one location/season to another thus clean seeds and resistant varieties in an area can minimize threats of diseases provided its current occurrence status is known. Common bacterial blight (CBB), Angular leaf spot (ALS), Rust, Anthracnose, Ascochyta, Scab and virus are the major bean diseases important in this region. CBB and ALS were found in almost all locations of the project while UYOLE 03, UYOLE 04 and UYOLE 94 were found resistant in most locations and no variety was susceptible in all locations. Most varieties were exchanging resistance and susceptibility among locations indicating high pathogen variability in the region. Resistant varieties, seed sorting and use of fertilizer were found to be the best management options. Resistant varieties in each location can be recommended to farmers together with the use of fertilizer and seed sorting as options for disease management in respective areas while Isimani is recommended for seed production as CBB is the only disease available. Having known the current disease occurrence status of the region, more management studies can now be easily carried out.

Paper Number: 1492 (Poster Number: 364)

Genetic Diversity of Ugandan *Rhizoctonia Solani* Isolates from Common Bean.

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The genus *Rhizoctonia* represents taxonomically disparate groups of fungi which causes root rots of common bean. In order to effectively breed for resistance to root rots caused by *R.solani*, elucidation of evolutionary relationships between different isolates of the same pathogen is important. Inter simple sequence repeat (ISSR) markers which are not only neutral and hypervariable but are also widely distributed throughout the genome make it possible to understand the existing genetic diversity. From our findings, the ISSR markers showed a high degree of polymorphism (0.85 ± 0.436) making them very useful tools to study genetic diversity. However, the genetic diversity among the isolates was low (0.345-0.394) suggestive of the existence of anamorphic (asexual) clades of *R.solani* and whence the limited evolutionary progress of the pathogen. Cluster analysis revealed 3 main clusters. These clusters could be indicative of slow mutation events and selection pressure resulting in novel phenotypes. Furthermore, the molecular groups were neither correlated with genetic diversity nor agroecological zones. Although the groupings partially corresponded to the anastomosis groups (AGs) of the isolates, some isolates did not cluster within any AGs.

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Given the limited diversity of *R.solani*, efforts to develop resistant cultivars should be accelerated to keep abreast of the pathogen. This has practical implications for breeding systems in Africa where seed is freely exchanged between families, communities, districts and agroecologies.

Paper Number: 1494 (Poster Number: 366)

Genetic Characterization of Angular Leaf Spot Resistance in Selected Common Bean Landraces from Tanzania.

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Angular leaf spot disease (ALS) caused by *Pseudocercospora griseola* is one of the most important bean diseases in Tanzania. The bean landraces Beti-10, Nanka, Nanavala and Nkanamna used in this study have been identified as resistant to ALS but the nature of inheritance and mechanisms of resistance against ALS in those potential sources has not been elucidated. This information is crucial and a necessary step for a successful breeding programme. The objective of this work was to study the inheritance of ALS resistance in those landraces and to identify the mechanisms of genetic resistance using Simple Sequence Repeat (SSR) markers. Crosses were made between resistant bean landraces and a susceptible bean cultivar Kablanketi. The parents, F1, F2 and backcrosses derived plants were used for inheritance studies and for molecular marker screening using 30 SSR markers. Results indicate that, a single dominant gene control resistance against ALS in each of the four landraces; also the SSR marker Pv-ag004 was found to be polymorphic between Beti-10 and Kablanketi and linked to the disease resistance. The resistance was validated by checking the F2 population of the cross between Kablanketi × Beti-10. Therefore, since marker Pv-ag004 is polymorphic and linked to ALS resistance, the landrace Beti-10 might be a potential source of ALS resistance. However, a detailed study with more markers is needed to be done on these landraces aiming at identifying new markers linked to ALS resistance and mapping of genes associated with resistance to ALS.

Paper Number: 1495 (Poster Number: 367)

Yield Loss Associated with Common Bean Rust on Germplasm Evaluation in Uganda.

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On dry beans (*Phaseolus vulgaris* L.), rust caused by *Uromyces appendiculatus* (Pers. Unger), brings about premature leaf chlorosis, senescence and in severe cases complete plant defoliation resulting in decreased pods per plant and weight of seed. This leads to extensive yield loss ranging from 18-100%. Rust has been observed to be an emerging disease in Uganda where it is continuing to devastate farmers' field unabated. To demystify the severity of this disease, a study was conducted to quantify the yield loss attributed to bean rust on a set of collected germplasm and in addition identify resistant genotypes to utilize in the breeding programme. Using an alpha lattice experimental design in fungicide treated and untreated experiments plots, 138 dry bean accessions were evaluated under field conditions. Results observed indicated that the yield of different bean accessions was significantly (P

Paper Number: 1496 (Poster Number: 368)

First Report of Cowpea Aphid Borne Mosaic Virus Infecting Cowpea in Zambia.

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We report the complete nucleotide sequence of a Potyvirus infecting cowpea in Southern and Western Zambia. Sequence comparisons indicated that the isolate under study has nucleotide sequence identity (91%) with cowpea aphid borne mosaic virus. Cowpea aphid borne mosaic disease was prevalent in all the three districts surveyed with highest incidence being in Choma (74.4%) and Mongu (71.9%).
Keywords: cowpea, potyvirus, sequence.

Paper Number: 1497 (Poster Number: 369)

Common Bean Pests and Diseases in Angola.

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Among the diverse legume crops produced by the smallholder sector in Angola are: cowpea, bambara nut, soybean, pigeonpea, lablab and common bean. The latter is the most important one, and is produced in diverse environments. However, its production is constrained by a number of factors, including low soil fertility, pests and diseases in the first season (October - December), and terminal drought in the second crop season (February - May). A study was conducted to establish major pests and diseases of economic importance, and their integrated pests and diseases management (IPDM) practices adapted. The results showed that, the diseases were caused by bacteria, fungi and viruses. The most important diseases were: common bacterial disease, anthracnose, angular leaf spot, root rot, ascochyta blight, rust and bean common mosaic virus. The disease samples were collected from host plants in various agro-ecologies for analyses and identify the pathogens. The most important pests were: *Ophiomyia* spp., *Agrotis* spp., *Spodoptera* spp., *Helicoverpa armigera*, *Maruca testulalis*, *Aphis* spp., *Tetranychus urticae*, *Mylabris* spp., *Acanthoscelides obtectus*, *Zabrotes subfasciatus*. Among the common IPDM practices were: crop rotation, use of genetic resistant and use of organic pesticides, as use of inorganic pesticides has not been common among smallholder farmers engaged in legume production in Angola. It is these IPDM practices that are being promoted by government and NGO extension system to promote bean production in Angola.

Keywords: Angola, legumes, diseases and pests management

Paper Number: 1498 (Poster Number: 370)

Occurrence and Distribution of Angular Leaf Spot of Common Bean in Zambia.

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Angular leaf spot (ALS) caused by *phaeoisariopsis grieola* (Sacc.) Ferraris is considered as the most important disease of common bean in the tropical and subtropical regions. The disease has been reported in more than 70 countries worldwide. Although the disease has been found to occur in farmers' fields in Zambia, no study has been made on its occurrence and distribution. Therefore, the study was conducted in five districts to assess the incidence and distribution in April 2014 in Northern Province of Zambia. In all the districts, ALS was found wide spread with a mean incidence of 19.4%. Isoka district registered the highest incidence (37%), while Mwense district recorded the lowest (3.2%). In order to manage the disease and assist the smallholder farmers obtain high yields integrated disease management is required. Keywords: *Phaeoisariopsis grieola*, incidence, distribution

Paper Number: 1499 (Poster Number: 371)

What Soybean and Haricot Bean Technologies Pre-Scaling up Have Brought about: Evidence from North Western Ethiopia.

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This study was aimed at investigating change on production and productivity of grain legumes due to agricultural research for development initiative taken by Ethiopian Institute of Agricultural Research to promote on shelf technologies through to agricultural technologies pre-scaling up activities and assess the seed system in North western Ethiopia using percentage, growth rate and tabular analysis. The study revealed that over the years area, production and yield of soybean and haricot bean have increased substantially. The increase in production was mainly due to area expansion for soybean while it was due to yield increment for haricot bean. The increase in yield for both crops was mainly due to use of improved seed and agronomic practices since fertilizer consumption was negligible. The area expansion in part could also be due to improvement in the relative profitability of grain legumes because of yield gain. Pawe Agricultural Research Center has played multiple role as source of proven technologies, foundation seed, training, supervision and quality assurance for the informal seed system have produced 881 quintal of soybean and 153 quintal of haricot bean which have reached thousands of farmers. Agricultural technology pre-scaling up activities have also disseminated 89.35 quintal of soybean and 33.5 quintal of haricot bean quality seed in 2014 alone. These efforts have brought about narrowing the yield gap by about 64% for both of the crops. However, there is still a huge yield gap for grain legumes in the area which could be achieved through strengthening the seed system.

Paper Number: 1500 (Poster Number: 372)

Dryland SEED Limited Experience in Legume SEED Production and Commercialization in SEMI-Arid Areas of Eastern Kenya.

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Seed is an important input agricultural activities. In semi-arid eastern Kenya, small; scale farmers are the main producers of bean, pigeon pea, cowpea and green grams. These farmers source their legume seed from the local grain stores which are within their reach. Quality of seed from this sources is not determined and seed germination and seedling vigor depends on chance. As a result, many farmers end up doing multiple planting sessions which increases cost of production, leads to non-uniform crops and low yields due to late planting. Dryland Seed Ltd (DSL), an emerging private seed company, based in Eastern Kenya pioneered in production and marketing of certified seed of drought tolerant legume varieties under license by KALRO and experienced a very low sales of the four legumes. DSL in collaboration with CIAT and KALRO used new approaches like demos, field days and the small seed packs to enhance farmers' purchase of improved legume varieties. In 2012, the sales of beans, cowpeas, green grams and pigeon peas were 7, 5, 10 and 1 tons respectively which increased to 200, 37, 34 and 10 tons respectively in 2014. The increase in sales was as a result of the farmer's good experience after using the high quality certified seed in terms of germination rate, high seedling vigor and productivity. More business opportunities was created by expanding the stockists outlets. These stockists also brought certified seed closer to farmers solving a key problems of lack of good quality seed in ASALS at planting times. Key words: legume seed, private public partnership, access to new improved varieties, and business opportunity

Paper Number: 1501 (Poster Number: 373)

Nurturing and Supporting Private Companies to Deliver Quality Seed to Small Holder Farmers in a Sustainable Manner.

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In Uganda, in the 1990s, bean seeds supplied through the formal system exhibited poor quality e.g. low germination, low yields and admixes. Smallholder farmers who formed the bulk of bean producers had limited access to quality seed of improved bean varieties. Since 2000, the National Crops Resources Research Institute ; International Centre for Tropical Agriculture/ Pan African Bean Alliance started providing technical support to Community Enterprises Development Organization (development organization) e.g. improved bean varieties that are early maturing, high yielding, market preferred and stress tolerant for multiplication and distribution alongside technical package on cost effective crop management practices. However this was development intervention to support small holders improve their livelihoods. As demand of quality bean seed increased, in 2005, CEDO opted to venture in bean seed multiplication as seed company as opposed to a community seed producer in order to tap the premium price offered for bean seed. Using the initial skills, the production costs remained lower and efforts were also geared toward enhancing capacities of the farmer seed producers under contracts. Wider dissemination of information during field days and participatory variety selection, seed fairs and exhibitions and use of small packs enabled access to information and viable seed to remote farmers. CEDO seed production increased from 149.1 tons with only two varieties released in 1980s in 2010 to 389.1 tons with 10 varieties released after 2010 in 2013 and marketed through 10 agro dealers using small packs. This demonstrates that with a target technical support, capacity building and continuous linkage with research organizations and variety demand creation, a farmer organization can evolve into seed company.

Paper Number: 1502 (Poster Number: 374)

Experineces of Legume Testing, Official Release and Seed Production in Kenya.

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Seed is an important input in agricultural production. In Kenya, over 90% of farmers use farm saved seed or seed from grain stores. In most cases, the seed is of low quality leading to farmers using high seed rates. Currently there is high export demand and local processing leading to legume commercialization. This requires legume grains of good quality. Legume release process and commercialisation offers a good opportunity to offer the industry good quality seed of new improved varieties. To enhance formal seed production and dissemination, the government liberalised the seed industry to allow many players. In early 1990s only one company was allowed to produce and market seed. Currently, there are 9 companies' marketing legume seed while 2 are exclusive to French beans. From 2004 to 2015, 140 varieties were entered in national performance trials (NPT) by public institutions (one research institute and 4 universities), 38 varieties by private seed companies and 10 varieties by CGIAR centre. 40 varieties of 9 legumes crops were officially released by public institutions while private seed companies released 11 varieties of 6 legumes crops.

Legume seed production of new varieties has been slow. To enhance submission of legume varieties into NPT, several breeders are encouraged to pool varieties and submit into NPT. To improve on representative variety testing and enhance release, more sites are encouraged. Release without improving marketing, varieties will remain in selves. There is need to increase participation of agro-dealers in legume marketing and need for joint marketing and promotional activities. Key words. KEPHIS, NPT, seed merchants, seed marketing, variety release .

Paper Number: 1503 (Poster Number: 375)

Raising the Profile of the Common Bean: Starting with Integrated Seed Systems and Gender Equity in Kenya.

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In sub-Saharan Africa, the common bean (*Phaseolus vulgaris*) plays a crucial role in human food, nutrition and economic security. Interestingly, its cultivation brings about sharp gender disparities. Women in much of sub-Saharan Africa are more active than men in production of legumes but incidences of poverty are higher in women as they lack access to and control of productive household assets. In Kenya, the common bean is undoubtedly a woman's crop as it is mainly grown and marketed by women. However, when the bean is mature, it gets more commercialized and there is a tendency of a shift from a woman's crop to a man's crop. This inevitably negatively affects the social and economic status of women. For the Kenyan smallholder farmers, this legume doubles up as a cash crop for regular income and as a subsistence crop for food. Despite this heavy reliance on the common bean, the farmers still struggle with: access to good quality seeds, improved varieties and inadequate marketing approaches of the bean seeds. However, many new varieties with great potential to improve production have been developed and released through joint efforts by the Kenya Agricultural and Livestock Research Organization (KALRO) and the National Regulatory Authority for seed industry, Kenya Plant Health Inspectorate Services (KEPHIS). This is as a result of increasing interest in improved bean varieties which respond to the farmers' priority needs to increase productivity and also with good marketability and good cooking qualities. Unfortunately, most smallholder farmers, women, are not aware and thus are not using them. Farmers obtain seeds through formal and informal channels, with the latter constituting the largest source for small scale farmers. In the informal channel, farmers rely on their own farm saved, seed exchanges among farmers and/or local sources for cultivation. This can be attributed to the low and poor involvement of both the public and private sector. Generally, legumes do not attract private sector attention due to several reasons: the self-pollinated nature allows farmers to save their own seeds and they also have a low multiplication ratio. Innovative and impact oriented legume seed systems have been tested and deployed in some countries in Eastern Africa. This has been through initiatives such as the Tropical legumes (TL-II) Project and Pan Africa Bean Research Alliance (PABRA). Through this, positive impact has been felt for millions of small scale farmers. However, the initiatives of these models need to be widely shared and scaled up so as to improve the overall performance of the regions legume seed systems and in this case: the common bean. There is therefore an urgent need to reshape and reposition the bean seed systems with special regard to gender equity for more socially, economically and environmentally sustainable agriculture in Kenya. The first key research question is to establish the advantages of an integrated seed system over the individual formal and informal seed system. This involves various stakeholders: public, private sector and donors working together with both male and female farmers. The second is establishing the impact of improved marketing approaches and access to information on new bean seed varieties. This involves use of effective dissemination pathways by partners so as to promote and sustain the bean value chain with keen interest on seed systems and that this information is accessible to both genders equally. A literature review of recent studies on legume seed system development in sub Saharan Africa was undertaken to gather insights towards the research questions. The studies reviewed include published reports and case studies. The first key finding is that involvement of stakeholders (public institutions, private organizations and donors) and smallholder farmers in the bean value chain has greatly improved the bean seed system. The integrated system is thus more beneficial. Seed produced by seed producers (for example KALRO) is known as breeder seed. When the breeder seed quantity is bulked up, this is foundation seed and when this is bulked up, it is certified seed which is sold to farmers. Through this there has been increased release of varieties that have better traits depending on the farmers' agro ecological zone hence better yields. There has also been increased access to farming inputs and agricultural technologies. A key point in the integrated system is that there is increased access to seed loans by farmers coupled with micro-finance initiatives. This is especially helpful to women small holder farmers who are often economically disadvantaged. This economic boost is provided by public or private organizations. Second is market led approaches that transcend the divide between formal and informal seed systems. This is through improved marketing systems and access to information about varieties by farmers and traders. This increases uptake of new varieties and hence is a motivating factor for private organizations to further invest in the bean sector. The standard marketing tools of the formal seed industry have been field demonstrations, agricultural shows and posters. However, with increased mobile phone use, even among smallholder farmers, a new marketing approach has been creation of more systems for mobile phones feedback that engage large scale traders and thus utilize their market experience in bean varieties. An innovative marketing approach has been small packaging of the seeds to increase affordability to smallholder farmer. This has been favorable to the women farmers whose purchasing power is usually low. Another boost in the marketing front has been introduction of the structured trading system (STS) courtesy of the East African Grain Council (EAGC) which has a presence in 10 countries. The core members include farmers, traders and processors. Through a structured trading mechanism, the farmer will ultimately experience higher profits hence sustainability of bean farming. Integrated bean seed system and innovative marketing approaches are the way forward in raising the profile of the common bean for improved agricultural productivity that will lead to improved food, nutrition and economic security. Furthermore, this will not only improve women's employment opportunity, income and efficiency but will most importantly provide social and gender equity.

(Poster Number: 376)

Innovative Chickpea Seed and Technology Delivery Systems in Eastern and Southern Africa (ESA).

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Chickpea seed business attracts limited attention by the private sector mainly due to erratic demand occasioned by self-pollinated nature enabling farmers to use farm-saved seed. Since 2007, ICRISAT through the tropical legumes project (TLII) worked closely with partners in ESA to develop innovative approaches based on seed roadmaps to fill up this gap. Between 2007-2014, 112t of breeder, 1037t of basic and 15,329t of certified seed of farmer-preferred improved varieties was produced by various project partners while 2685t of seed involving 22 varieties were produced directly by the project (Ethiopia-1,998t, Kenya-372t, and Tanzania-315). In Ethiopia, 18 seed grower associations were formed and their capacities enhanced for quality seed production. One of these was recently registered as a private seed company. In Tanzania, seed delivery was mainly in partnership with NGOs and a few private companies. In Kenya, links were established with the private sector, farmers' cooperatives, farmer training and field schools, NGOs and community organizations. These approaches led to widespread adoption of new and some on-the-shelf varieties. TLIII will support partner efforts to scale up/out sustainable seed production and delivery lessons learnt in TLII, with particular emphasis on female seed producers working through establishment of multi-stakeholder seed delivery platforms.

Paper Number: 1505 (Poster Number: 377)

Enhancing Production and Dissemination of High Quality Improved Legume Bean Seeds to Small-Scale Farmers in Central and Northern Parts of Rift Valley in Kenya for Increased Nutritional Security and Incomes.

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In Kenya approximately four-fifths (78%) of all seed grown is not certified and produced by informal sector, except for maize despite large number of released varieties from research. This project aimed at enhancing production and supply of high quality improved seeds to farmers for improved food security in six counties in Rift Valley Kenya. The bean varieties multiplied included newly released Chelalang, Tasha, KK8, Ciankui. Several chickpeas, groundnuts and Pigeon Peas were bulked in small quantities. The certified and quality declared seed (ADS) was made available in small packs ranging between 0.25-2Kg for small scale farmers. Awareness among farmers on the availability of the seeds was created through various ways like media programs and demos in schools and farms. Retail outlets, agro-dealers and farmer cooperatives were recruited to improve the access of the seed to farmers. Foundation/breeders seed in collaboration with other seed companies like Faida, Agrosoy, Premier and Leldet Seed Companies was also increased resulting in overall access of improved bean seed availability from 2011 to 2015 to over 200,000 farmers. Over 500 contract growers was also involved in collaboration with NGOs, CBOs and seed companies. The high increase in production between 2013-2015 was due to funding support from AGRA which enhanced capacity of Egerton Seed unit. Newly released varieties for legumes to farmers was enhanced by bulking, distribution, farmer demonstrations in a wide partnerships. Farmer-to-farmer exchange of seeds at farm level also increased. The model ensured farmers get access to improved seed of key crops for increased production

Key words: Certified and QDS, promotion, demos, partnerships, seed units,

Paper Number: 1506 (Poster Number: 378)

Analysis of Common Beans Varietal Selection and Constraints for Bean Production and Marketing in Mozambique.

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Despite its socio-economic importance, many farmers do not adopt many varieties of common beans disseminated by IIAM or abandon right after the on-farm experimental trials. Socio-cultural aspects, market demand, consumers' preferences, morphological and agronomic characteristics of different crop varieties are all relevant for adaptability, social acceptability, and consequently, for the adoption of new varieties.

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While any successful bean variety should be adapted to stressful agro-climatic or poor soil conditions, it should also meet some specific needs of the farmers and their socio-cultural environment. This study assesses relevant features in the choice of the cultivated common beans varieties by the small-scale farmers, and proposes some areas to be addressed by research in common beans subsector. A three-stage purposive sampling method was used to select 18 communities, in eight districts within three provinces. A Participatory Rural Appraisal was applied to gather primary data. Common beans are ranked in the top two crops for both consumption and income generation. There is a diversity of varietal preferences; however, there are differences in consumption habits in different regions, farmers living along the border prefer darker colored beans while the farmers living in the interior prefer butter beans to supply the national market. Positive attributes for varietal preferences include good price, good yield, good gravy and good taste. The main negative traits that should be addressed by research include intolerance to excess water, short lifespan after cooking and susceptibility to pests. Research should also address the development of varieties adapted for production during dry period.

Paper Number: 1507 (Poster Number: 379)

Using Subsidized Seed to Catalyze Demand Driven Bean Seed Systems in Malawi.

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Beans are the most important food and cash legume in Malawi. Its production is low and failing to meet increasing demand. Several improved bean varieties have been released by the Malawi National Bean Program (MNBP) in collaboration with CIAT. However use of the varieties by farmers has been impeded by lack of reliable and sustainable seed delivery system operating at a wider scale. This study describes the process of building private-public partnership (PPP) to stimulate wider delivery of bean seed as well as to build a foundation for demand driven and sustainable bean seed systems. Through a six step process public-private collaboration for producing and delivering improved bean seed was built. Through this PPP Demeter Agricultural Limited (DAL), along with MNBP and CIAT, supplied 2559 tons of certified bean seed between 2009 and 2012 through the governments Targeted Farm Input Program. Results of a follow up study showed that farmers were satisfied with the variety supplied, timeliness of the operation, pack size and information provided. Without the TFISP farmers are willing to pay for a 0.5kg seed pack. Growing numbers also accessed new improved varieties, from 264,661 households in 2009 to 344,200 in 2012. These emerging farmer demands and the subsequent DAL responses suggest a base for building sustainable delivery systems. The PPP aligned to the TFIP has been crucial for building capacity of bean seed multipliers. Hence PPP could be repeated for other legumes. However, decentralized seed-based systems will be needed for promoting varieties suited to micro-ecological niches.

Paper Number: 1508 (Poster Number: 380)

Taking Improved Grain Legume Technologies Beyond the Demonstration Plot.

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Grain legumes are one of the major components of farming systems in smallholder agriculture of sub-Saharan Africa (SSA). Soybean (*Glycine max*) and pigeonpea (*Cajanus cajan* (L) Millsp.) are two legumes with huge underexploited potential, for example Africa only supplies 15-20% of the pigeonpea global demand of 5 million MT. They could also contribute significantly to soil fertility through biological nitrogen fixation. Despite their importance, the productivity of these crops is very low, typically under 1.0 ton per ha. This could be more than doubled if the following were improved: awareness of good agronomic practices including the use phosphorus-containing fertilizers and rhizobium inoculum, use of unimproved seeds and access to profitable markets. It is against this background that AGRA's Soil Health Program (SHP) took a value chain approach to improving smallholder farmer productivity of the two grain legumes in 5 countries in eastern and southern Africa region. Additional intervention of the approach that was dubbed 'going beyond demos' included strengthening farmers organizations and improving access to affordable credit. This process required fostering of strategic public and private sector partnerships. After 3-4 years of implementing the interventions, 251,000 smallholder farmers scaled up legume production to at least 0.25 ha per household and yields increased by 50 to 100%. Cumulative produce of the two crops over 3 years is estimated at US\$53 million, more than double the investments made. There is need to build on the gains made and the approach used to scale up the productivity of the two crops in Africa.

Paper Number: 1509 (Poster Number: 381)

Characteristics of SMALL Holder Bean Farmers, SEED Preference and SEED Sources in Selected Bean Corridors of Kenya.

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One of the limiting factors to bean production and productivity in Kenya is limited availability of improved bean varieties seeds. This paper analyses variety preferences and sources of seed by small-scale farmers. The paper uses survey data collected between June and August in selected major bean corridors in Kenya. A questionnaire was administered on 415 farmers. The data collected were subjected to descriptive analysis of proportions and percentages. Results show that about 43% of bean farmers would select seeds of varieties based on high potential yield and 32% on consumer preferences, while 25% would select readily available and affordable varieties. Results also revealed that farmers' could be elicited with varieties that meet production challenges (high yields) and market needs (consumer preferences). About 85% percent of farmers planted farm saved seeds. Ten percent obtained seed from local traders while only 2% two percent purchased certified seed. There exist confusion in the naming of common bean varieties, hence there is need for researchers to identify, harmonise and document existing varieties. It was observed during the survey that farmers grew beans that are demanded by the consumers for example, in Homa bay County, despite work done on dissemination of the improved bean varieties, farmers preferred growing a local bean variety which was preferred by over 70% of the respondents due to its taste. we recommended that the bean seed system could be improved when bean crop breeders and seed producers regularly evaluate the dynamics of consumer preferences and continuously generate varieties that satisfy them.

Paper Number: 1510 (Poster Number: 382)

Unlocking Pre-Basic Bean Seed Supply Bottlenecks through Mutually Beneficial Public-Private Sector Partnerships in Malawi and Zimbabwe.

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Opportunities arising in legume, including bean markets in Sub Saharan Africa are obstructed by lack of quality seed, despite emerging interest from private seed companies. Production of certified seed is liberalized, but the production of pre-basic and basic seed in most countries remains a preserve of the public sector. Inadequately resourced, the public sector often produces insufficient volume of early generation seed resulting in delayed use of newly released varieties. In response, public research institutions and private seed companies resolved to jointly produce breeders' and pre-basic seed of new bean varieties on cost-sharing schemes in Malawi and Zimbabwe. In Malawi, a seed company and the Department of Agricultural Research Services (DARS) contribute to meeting expenses in early generation seed production: seed, land preparation, fertilizer and backstopping visits. After harvesting, the seed company and DARS share seed in a sharing ratio of 3:1 respectively, in recognition of contribution to meeting production expenses. In Zimbabwe, seed companies pay royalties of 2.5% of gross annual bean seed sales to the Crop Breeding Institute (CBI). Instead of paying cash, some parastatals pay royalties in inputs, thereby enabling CBI to produce breeders' seed during the rainy season and off-season. Recently, GRM International, which set up Zimbabwe Super Seeds (ZSS) financially supported CBI to produce bean breeders' seed, which was in turn sold to ZSS. In both countries, private seed companies received technical backstopping and pre-basic seed production of new bean varieties increased tremendously for instance, up to 10-fold within one calendar year in Malawi.

Paper Number: 1511 (Poster Number: 383)

Assessing the Potential Demand for Improved Bean Variety Seeds in Malawi.

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Bean production in Malawi is severely constrained by a host of biotic and abiotic factors, requiring frequent cultivar and seed replacement to achieve higher yields.

Thirty improved bean varieties were released over a 30-year period, but few bean growers have accessed them due to lack of awareness coupled with inefficient distribution systems. Past efforts to disseminate bean seed were limited in coverage, and overlooked private sector participation and farmers' demand. This study examines the potential demand for certified seed of new bean varieties by investigating farmers' willingness to pay for seed to compensate for cost of production and marketing. It also estimates the size of the market and profiles the farmers that are likely to demand for seed. Data from a survey of a representative sample of 400 households from Malawi in 2012 were analyzed by simple descriptive and econometric methods. Results indicated that 80 percent of the farmers were willing to pay for bean seed of preferred varieties at MK238-353/kg. Production costs of certified seeds were estimated at MK129.21 per kg while retail price was MK 600 per kg. Farmers considered expanding scales of production using bean varieties with all desirable attributes and 46 % expressed willingness to purchase seed every season or once in two seasons. The most important drivers for demand for improved bean seed were determined as being young, producing on a larger scale and being in village with a market for agricultural produce.

Paper Number: 1512 (Poster Number: 384)

Linking Bean Seed Company to Reach Smallholder with Improved Bean Seeds.

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Access to certified bean seed in Tanzania is still limited. Very few companies are marketing beans seed. The Agriculture Seed Agency (ASA), a state enterprise was usually selling low amount of seeds packed in 50 kg bag mainly targeting development/relief organizations rather directly selling to farmers. The bean seed sales were very limited and more often they used to carry a stock for two years. The project named "Unlocking the potential of seed companies to reach smallholders with improved bean varieties in northern Tanzania" which was initiated early 2015 supports ASA to understand farmer's seed demand (variety, quantity and use) and create awareness on the use of improved bean seed varieties. As a marketing strategy the project established 88 demos, conducted 4 field days and participated in one farmer's show. The events have attracted about 2000 people including the politicians, senior government staff, private companies (seed and other related services) and farmers who learned on common bean production and use of quality seeds. ASA has been able to identify four varieties which are highly demanded. Between October to December 2015, ASA sold 15 MT through agro-dealers network which formerly would take a year to sell. The seeds are sold in small pack size of 2kg which are affordable to poor resource farmers, including women. It expanded sales to Kagera region (5 tons). Twenty tons more are expected to be sold in March 2016 crop season. Furthermore ASA is now increasing bean production area from 40 hectares to 140 hectares.

Paper Number: 1513 (Poster Number: 385)

Profitability and Growth Prospect of Community Based Seed Production Enterprises. the Case of Common Bean in Southern Rift Valley, Ethiopia.

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In Ethiopia, there is limited multiplication and distribution of self-pollinated crops seed by the formal seed sector. The formal sector is instead more devoted to wheat, maize and horticultural seed production. Common beans (*Phaseolus vulgaris*), which is an important crop both for export and domestic consumption, is one of the crops neglected by the formal sector. In order to fill this gap, national research systems and international research organizations introduced farmer-based seed system. This study explores the economic viability of farmer-based seed multiplication of common beans. The study assess the profitability of farmer-based community based seed multiplication enterprises using gross margin analysis, investigates the profile of farmers taking up seed multiplication as an enterprise using tobit model, and factors affecting choice of seed source using multivariate probit model. The study used data from 195 farms from the southern rift valley in six randomly selected kebeles. Results reveal that farmer-based seed enterprises are profitable (56.6 % to 73%) and farmers who are wealthier and close to township are more likely to take up seed multiplication enterprise. Farmer organization, promotions through extension services and remoteness are the external factors that exert a positive influence on decisions to purchase seed from farmer-based seed enterprises. The finding provides robust evidence on the profitability of farmer based seed multiplication and allow the private sector to invest in seed multiplication. The finding also help government and non-governmental organizations who are working with common beans seed to design efficient seed delivery models to avail improved seed to smallholders.

Paper Number: 1514 (Poster Number: 386)

Innovative Beans Seed System for Smallholder Farmers-Experiences from Southern Highlands of Tanzania.

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Common bean (*Phaseolus Vulgaris* L.) is one of the most important crops; providing incomes and food to millions world-wide. In Tanzania, the crop's increasing demand for domestic and export market is often choked by dwindling production due to insufficient supply of high quality seed. ARI-Uyole designed a partnerships approach to avail quality seed of improved bean varieties to smallholder farmers through linking participatory variety selection, to capacity building in seed multiplication and marketing. This paper presents the success of the approach implemented through participatory variety selection, seed multiplication and marketing. In 2008, ARI-Uyole provided 2kg start-up seed to each of ten demonstration sites in Mbozi district, a move which stimulated seed demand. In response, two farmer groups produced 6.29 tons of quality declared seed (QDS) in 2011, increasing to 7.15 tons in 2012. This attracted Nkasi District Council and a private seed company, Beula Seeds resulting in the production of 557.32 tons of QDS and 43.0 tons of certified seed by 2013. From the partnerships in Mbozi district, Raphael Group Ltd purchased 62 tons of grain of one bean variety worth USD55,800 in 2013-2014, pioneering demand for unmixed bean grain. Consequently, tree and tea growers in Mufindi and Njombe Districts have adopted bean as a fast income generating crop, collectively purchasing 283 tons of bean seed in 2015. Seed production for previously unknown bean is driven by the growing customer-base. Success hinges on links to lucrative markets that demand production of farmer-preferred varieties selected using a participatory approach.

Paper Number: 1515 (Poster Number: 387)

Paradigm Shift in Common Bean Production, Productivity and Marketing through Generation and Promotion of Demanded Common Bean Varieties in Ethiopia.

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In Ethiopia, common bean breeding has been done through introduction of advanced germplasm from the CIAT and local cross making and evaluating the genotypes across years and locations. Through PABRA, bean varieties with known market attributes have also been imported and went through fast tracked evaluation and best ones released. In situ population development was also carried out and the varieties were evaluated for the target market classes. The release sought to cover the navy bean with broader export market class, regional markets with high value types including sugar bean and local as well as regional preferred small red market. Clients and stakeholders were consulted when setting the breeding goals, trait prioritization, during implementation, monitoring, learning and evaluation. While promoting the bean based technologies, common bean value chain actors were actively involved; choosing variety for promotion and seed production. Various methods were employed in variety promotion including; use of farmer research groups, enhancing quality declared seed, strengthening formal extension, partnering with farmer cooperatives unions, strengthening and stimulating formal seed system. Between 2004 and 2014, the synergetic efforts contributed to increased bean productivity from 0.615 tons/ha to 1.5 tons/ha, representing 243.9% increase. Area under beans has increased by 80%, from 181,600 ha to 326,465.88ha. Revenues from navy beans export alone increased from 20 to 100 million USD. The paradigm shift in bean productivity, production and market has improved the livelihoods of bean growers in the country. The value chain client-led bean breeding and promotion model can be adopted for other crops.

Paper Number: 1516 (Poster Number: 388)

Capacity Building of Farmer Groups for Good Quality Seed Production to Accelerate Adoption of Improved Bean Varieties in Northern Zone of Tanzania. Case Study of Kilindi District, Tanga.

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In Tanzania, access to and use of certified bean seed by farmers remains unsatisfactory. About 90% of seeds sown are farm saved, with uncertain quality characteristics including seed borne pathogens leading to low productivity. A decentralized seed approach was adopted to enhance production of Quality Declared Seed (QDS) with the aim of improving availability of quality seed at local level. The initiative was implemented by MUVI in partnership with Kilindi District Agricultural office with support from the Bean Programme at Selian Agricultural Research Institute and the International Center for Tropical Agriculture. The implementation process started with establishment of stakeholders' forums. Farmers were then trained on seed production and quality control. After the training, 18 of the participating farmers embarked on production of QDS. Twelve acres were planted and 4.85 tons of quality declared seeds produced. Seven demonstration sites were established in 7 villages to showcase the production of quality declared seeds for 6 improved bean varieties and 1 local landrace. The demonstration fields were also managed by the 42 participating farmers in collaboration with the extension officers. Regular field inspections were conducted to ensure adherence to the standards set by quality seed authorizing institute.

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To enhance adoption of the improved seeds, field days were conducted at harvest where 253 bean stakeholders including farmers participated. The Quality Declared Seed approach has increased access to quality bean seeds particularly for 267 smallholder farmers in rural areas characterized by poor infrastructure.

Key words: Access, declared, demonstrations, farmers, quality seeds, stakeholders

Paper Number: 1517 (Poster Number: 389)

Determinants of Sustainability of Community Seed Banks in Nicaragua.

David DeYoung and Mywish Maredia, Michigan State University*

Problem Statement

Long-term investment by national and international researchers has resulted in the development and release of bean varieties with increased yield potential. However, access by small holder producers to these improved bean varieties remains a constraint due in part to the lack of a private sector led seed multiplication and dissemination system.

Key findings

This study examines three types of Community Seed Bank (CSB) models implemented in Nicaragua in response to this development challenge. The study includes 154 CSBs that were part of a project that produced and disseminated Apta seed (i.e., Quality Declared Seed) to an estimated 24% of small holder bean farmers in Nicaragua. Using the duration analysis technique, the study found that the CSBs that produce quality seed, recover production costs, have experienced leadership, operate formally by documenting decisions, and have access to productive assets operate longer than CSBs lacking these characteristics. Seed marketing training was found to reduce the failure rate of CSBs despite low seed yield experienced by them in their first year of operation. The risk of failure increased with higher intensity of CSB operation as measured by the number of farmers receiving seeds per unit of CSB seed production capacity.

Significance

The above findings contribute to the growing recognition of the importance of decentralized models of seed production as part of integrated seed systems for legume crops. It identifies characteristic features of a community based seed production model that should be promoted to increase the probability of its long-term operation/sustainability.

Paper Number: 1518 (Poster Number: 390)

Access to More Improved Cowpea Seeds through Partnership.

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Abstract

The Heritage Seed Company (HSC) has been in existence for over 20 years. The company has been operating as a sole proprietorship with a lot of inefficiencies and limitations. Through an existing Savelugu Innovation Platform in Northern region, the company is now operating an out-grower scheme thus distributing the risks among other farmers, increasing her acreage and cowpea production from 1MT to 5MT in 2014. However, during the same year, he could engage only 75 out-growers out of the 100 registered farmers. As a result of her partnership with the USAID Cowpea project, the HSC this year had obtained/bought enough breeder and foundation cowpea seeds to be able to engage 158 out-growers - more than half the number engaged in 2014. Through this partnership, more farmers now have access to inputs, training, and would receive ready market and higher prices for their produce and therefore, increased income. Some of the farmers envisaged their potential of becoming independent registered seed growers in the near future. Women seed growers through the scheme in Northern Region is unprecedented. What is striking is that HSC is now able to supply more seeds to its customers and consequently distributing the gains within the communities. The company currently has 10 staff but its Managing Director has envisioned engaging more trained staff to man the various operations of the company in the near future. The willingness of the HSC to have small seed packages of 0.5, 1, 2, 5 kilograms (a milestone of the project) will also cater for smallholder farmers.

Paper Number: 1519 (Poster Number: 391)

Integrated Seed System for Increased Seed Availability and Higher Yields.

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Common bean (*Phaseolus vulgaris* L) is the most important legume for rural smallholder farmers in Uganda. However, its yield is still lower as a result of inadequate access to quality seed among other factors. Before 1994, only the Uganda Seed Company was supplying certified seed to government and relief seed operations. However, with the liberalization of the seed industry in 1994, several companies now operate in Uganda and since then to-date, 29 high yielding varieties with wider adaptation were released. Prior to 2011, 65% of seed supplies were through institutional markets in Uganda and from neighboring countries. This limited farmer access to quality seed of newly released varieties as supplies were dominated by varieties released before 2010. This paper highlights the successes of an integrated seed system implemented under Tropical Legume Project. In this approach twelve seed companies were engaged supported by decentralized seed enterprises. From 2012, over 73.9 tons of breeder and 292.05 tons of basic seed were produced. The seed companies increased production of certified seed from 1,069.7 tons in 2011 to 23,877.5 tons in 2014. The variety composition increased from two varieties released before 1980 to 10 with 20% of the supply being varieties released after 2010. Between 2012 and 2015, decentralized seed entrepreneurs produced 287 tons mainly with new varieties released after 2010. In addition they have contributed to promotion which increased demand of the new varieties. NGOs and NAADS assisted in training, information flow on new varieties and complementary crop management techniques.

Paper Number: 1520 (Poster Number: 392)

A Poster: Application of Monitoring and Evaluation and Geographical Information System on Accessibility and Utilization of Improved Bean Seed Varieties in Northern Tanzania.

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Common bean is the leading legume of small holder farmers in Tanzania, accounting for 78% of legume-cultivated land. It is estimated that over 75% of rural household depend on beans for their daily subsistence eating 19.3 kg per year per person. To sustainably harness the potential of beans for food and nutrition security in Tanzania, efforts need to be intensified towards improving accessibility and utilization of quality seed of improved bean varieties. International Center for Tropical Agriculture (CIAT) through the Pan Africa Bean Research Alliance (PABRA) have come up with the project named "Unlocking the potential of seed companies to reach smallholders with new improved bean varieties in northern Tanzania" implemented by CIAT/SARI, ASA and Meru Agro. Specifically this project will focus on seed multiplication, distribution, awareness and demand creation, building seed demand of farmers and strengthening linkages among stakeholder involved in bean value chain. In order to monitor effectively the outcome of the project Monitoring and Evaluation (M&E) and Geographical Information System (GIS) are being employed. The two have a fundamental difference: M&E is temporally focused - measuring changes and outcomes occurring over time and GIS is spatially oriented - identifying where the outcomes are occurring. Location based information can tell us more on stakeholders distribution, location of highly preferred variety, accessibility to farms and market, etc. Merging these two different views into one will display useful information in support of a successful outcome for the project. Remember a picture in this case a map speaks louder than words

Paper Number: 1521 (Poster Number: 393)

The Economics of Community Based Seed Production: A Case Study of the Association Song Koadba (ASK), Burkina Faso.

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The problem of lack of farmer access to seed has left millions of smallholder farmers relying on their own or other farmers' harvested 'grain' as the main source for seed. The characteristic of this so called 'informal' seed system is that the production and sale of 'seeds' is decentralized, takes place close to the community, and by a large and diverse sets of players. One of the advantages of the informal seed system is that it is able to meet diverse needs of farmers at lower cost. However, on the disadvantage side, the informal system is not directly linked with the research system, and thus not able to quickly channel new improved varieties to the intended end-users. Moreover, much of the seed production in the informal seed system takes place without any quality control. This increases the risk farmers experience in the form of low germination rate, seed-borne diseases, and poor plant growth, which negatively impacts the productivity of food production. In view of these challenges, this paper presents a case study of a farmer association in Burkina-Faso called Association-Song-Koadba (ASK), which is involved in training its members to produce quality declared seeds (QDS) of cowpea for sale to other farmers. Through this case study we investigate whether and how the ASK model builds on the cost advantages of community based seed production, and minimizes the disadvantages of potentially lower seed quality of an informal seed system.

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We identify the strengths and weaknesses of the model and derive principles of sustainability underlying the model for broader applicability to other countries.

Paper Number: 1522 (Poster Number: 394)

Enhancing Smallholder Farmers' Access to Improved Cowpea Seed at the Community Level in Northern Ghana.

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Abstract

Over the years, CSIR-SARI in collaboration with IITA has released several improved cowpea varieties with the aim of reducing poverty and malnutrition in Northern Ghana. However, these seeds have not come within the reach of the resource-poor farmers due to limited availability of the improved seeds. In order to enhance the accessibility of improved cowpea seeds through the TL III Project, SARI in partnership with USAID/IITA Cowpea Out-scaling Project and MoFA, engaged CBOs within the Upper East Region of Ghana in community seed production scheme to produce certified seed of cowpea to sell in their communities. The dry season production scheme was carried out in 5 Districts and 20 beneficiary communities from October –December 2015. In all, about 40ha of land was planted and with expected yield of 1t/ha, at least 40t of certified seed production was estimated under the scheme. The seed production is being accomplished with supervision from SARI and the Seed Inspection Unit of MoFA. A revolving system has been set up in which each farmer group after harvesting, returns 1.5 times the equivalent of seeds received from the project. The seeds recovered in the 2015 will be supplied to farmers from other communities during the 2016 cropping season. The participating farmers are encouraged to sell the rest of the seeds to members of their communities to expand farmers' access to the improved seed. The financial resource funded by the project through selling the foundation seed will help to continue the seed reproduction system sustainability.

Key words: Community, Cowpea, Smallholder Farmer, Access,

Paper Number: 1523 (Poster Number: 395)

Farmers' Willingness to Pay for Quality Bean Seed: Evidence from Central America.

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We use data from a survey of more than 1400 smallholder bean farmers who participated in a bean technology dissemination project in Nicaragua, Guatemala and Honduras to examine farmers' willingness to pay (WTP) for quality bean seed. Since bean 'seed' competes with bean 'grain' as planting material, we measure farmers' WTP for 'seed' relative to grain price. WTP for quality seed is assessed based on farmers' opinion on the payment agreement and how much they would be willing to pay for any additional seed. Results indicate that the quantity of seed demanded and the price farmers were willing to pay for additional seed varied across the countries. Percentage of farmers willing to pay for seed more than the average grain price ranged from 41% in Guatemala to 75% in Nicaragua. A very small percentage of farmers (<10%) were willing to pay for bean seed twice the average price of grain, which is the price of certified bean seed in many countries. This study provides evidence of farmers' WTP for quality seed with a premium over the grain price; but the amount willing to pay is highly correlated with the economic status of bean farmers. Results indicate that meeting the seed needs of farmers across the spectrum based on 100% cost-recovery principle and private sector led model will not be a viable option for legume crops in developing country setting similar to Central-America. Thus, scaling up efforts must be based on a two-(or multi)-pronged approach of subsidies and cost-recovery where possible.

Paper Number: 1524 (Poster Number: 396)

A Pathway to Small Farmer Success in Tripling Black Bean Yields in Guatemala.

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For decades, black bean yields have stagnated at less than 400Kg per hectare in the Guatemalan Western Highlands. Farmers and experts' opinions as to why yields have declined over time have pointed out to increased biotic and abiotic pressure triggered by a changing environment. The national scientific and the donor community have developed alternatives that can help farmers increase productivity. However, results in the past have been mixed since reaching farmers in remote villages where different languages are spoken can be an expensive and complex task.

Paper/Poster Abstracts

Despite the challenges, MASFRIJOL, a current initiative funded by USAID Guatemala, is confirming that innovative and customized approaches for remote rural communities can pay off. For two consecutive seasons, farmers have tried seed of improved varieties for the first time and experienced tripled and higher yields. This poster explains the project design process, farmer identification and networking techniques in the field to follow up on their results. Five case studies with proven yield increases are categorized, outlining the major factors of success: 1) customized community engagement approach; 2) building feedback loops with existing community support programs on what works and what does not; 3) identification and access to improved varieties to increase demand; and 4) promoting community leaders with the best results as sources of knowledge for other farmers. Aware of the challenges faced by the bean sector abroad, the poster offers the academic and practitioner communities an optimistic view on interventions aiming at valuing common beans as a worthy crop for small farmers. The experience accumulated by MASFRIJOL in Guatemala can also inform other innovations in seed systems as the project embarks in the promotion of community seed depots.

Paper Number: 1525 (Poster Number: 397)

Overview of Tropical Legumes Projects (TLI, TLII, TLIII) - the Chickpea Scenario in Ethiopia.

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The chickpea improvement and technology dissemination in Ethiopia has been supported by the Tropical Legumes Project funded by the Bill and Melinda Gates Foundation since 2008. The project had general objective of enhancing productivity and production of chickpea through supporting development of improved varieties and sustainable seed production and delivery systems. Hundreds of breeding lines were evaluated and crosses made to improve yield, seed size, disease resistance, drought and heat tolerance. The project contributed in the development and release of four kabuli (Monino and Akure, Kobo and Kassech) and three desi (Minjar, Dalota and Teketay) chickpea varieties from 2009-2013 regionally and nationally. The farmers' participatory variety selection approach and awareness creation through demonstration made follow up technology dissemination smooth and efficient. Dissemination of chickpea technologies focused on four major chickpea producing regions: Amhara, Oromia, Tigray and SNNP, where 15 zones and 55 districts were addressed. As seed production by the public and private sector is limited, the projects supported the establishment of 18 farmers' seed growers associations which became the nation's major chickpea seed source. More than 40t breeder, 700t basic and 12,000t certified/QDS seed of improved chickpea varieties were produced and distributed from 2008 to 2014. The national average productivity of chickpea increased from 1.3t to 1.9t while the production rose from 18.7 thousand tons to 42.4 thousand tons from 2008 to 2014, respectively. TLIII is set to scale up/out these successes for the next 4 years.

Paper Number: 1526 (Poster Number: 398)

Success of Chickpea Production in North Gondar Zone of Ethiopia.

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Chickpea is an important legume crop and plays an important role in human, animal feeding and soil improvement. With its diverse agro-ecology North Gondar zone is the largest chickpea production area in Ethiopia, where 16 out of its 22 districts produce the crop. In earlier interventions with the Tropical Legumes project improved chickpea varieties namely; Arerti, Habru and Natoli got wider adoption in Gonder Zuria and Dembia districts. In recent interventions in West Belessa and East Belessa districts variety Habru received higher acceptance by the farmers. The complete failure of the local desi cultivars in the two districts in 2014 due to *Ascochyta* blight resulted in a full scale adoption of Habru. Only in the second year of the intervention over 1200 farmers managed to grow this variety. Variety Ejere, the second choice of the farmers in participatory variety selection (PVS) has also good penetration in these districts. Farmers' seed grower groups were established to make seed available in the farmers' vicinity in order to ensure sustainable expansion of improved chickpea technologies. The increment in chickpea productivity in the zone from 1.4 to 2.03 t/ha in 2009 and 2014, respectively, can be attributed greatly to the contribution of improved varieties. The average productivity of chickpea in the zone in 2014 exceeds both regional and National average. Efforts made towards managing biotic and abiotic stresses could further improve the productivity of the crop in the zone.

Paper Number: 1527 (Poster Number: 399)

Comparing Recent Community-Based Bean Seed Production Models: Challenges in Designing Sustainable Interventions and Lessons Learned.

Cynthia Donovan and Luis Flores, Michigan State University*

Over the last 5 years, a number of institutions have been working with three main community-based seed production models in Central America. The models and methodology to establish them vary in type of farmer organization, individual or group ownership and in the level of seed capital, training and monitoring provided. Because of the heterogeneity across communities and the resource-poor farmers targeted by these initiatives, experiences from Nicaragua, Honduras and Guatemala have shown that implementing an ideal "community seed bank" methodology is a task filled with major design challenges. This paper evaluates the breadth and depth of investments made by different organizations in three types of seed bank design models and the supporting methodologies provided by three major interventions. The first model is based on community-level participatory research efforts in two prominent common bean producing regions in Honduras which have evolved into a consistent source of improved seed for different communities for over ten years. The second model is based on the original Food and Agriculture Organization (FAO) methodology started in Nicaragua in the mid-2010s and further adapted by the Nicaragua National Agriculture Research Service throughout the country. The third model examined is based on the experience of the Honduran National Agriculture Research Service in two main bean producing regions. Findings in this assessment outline the importance of the initial investment, opportunities and threats to sustainability by the type of ownership promoted in the different models. Analyzing these recent experiences and contrasting their advantages and disadvantages offers relevant insights for on-going initiatives targeting seed systems development. As learned in this study, a number of design flaws can be prevented based on these experiences, particularly on the number of years or production cycles it takes for a farmer organization or individual seed producer to master the techniques of seed production and to ensure there is a market in the community and surrounding villages to motivate annual seed production.

Paper Number: 1528

Gender Transformative Participatory Research and Plant Breeding in Central America.

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The speaker will present a case of transformational participatory research and plant breeding that has been used among farmers in the steep hillsides of Honduras since 1993. In this approach skilled teams of farmers (CIALs), trained in the management of agronomic trials and trait selection, along with their NGO partners and breeders in the formal sector, have worked together to breed new varieties (PPB) of maize and beans. Some of the varieties originate in farmers' fields, others on experiment stations, but all the varieties involve decisions made by skilled farmers derived from their own agronomic trials. Bean evaluation shows that PPB varieties are highly valued by local farmers relative to both unimproved landraces and to conventionally-bred materials. Mass evaluation of selected PPB materials at a higher geographic scale shows similar results, supporting the broader goal of national release of PPB seed. Farmer researchers, who were typically among the more marginalized members of their communities, now have skills that have contributed to recognition within their communities, and to personal self-esteem. This is especially true for women CIAL members, who make up about 45% of the membership. Like most other rural women in Honduras, they formerly had no decision-making role in agriculture. Now these women are respected for their agricultural knowledge - not only within their own households but also by others in their communities and municipalities. Empowering women through agricultural research and associated skills development has been accepted by some men because of the perceived benefits, both economic and social, at the household level.

Paper Number: 1529

Incorporating Gender-Sensitive Traits in a Bean Breeding Program.

Stephen E. Beebe, International Center for Tropical Agriculture (CIAT) and Enid Katungi, Centro Internacional de Agricultura Tropical (CIAT-Uganda)*

Many farmers around the world and especially in Africa are women. If agricultural innovations are to be effective, gender is a critical variable. Farmer surveys comparing trait preferences of men and women reveal that some are in common and some are unique to women. Both men and women give high marks to yield and to grain traits that affect marketability, but in Uganda women express greater preference for drought tolerance and disease resistance. On the other hand, men and women both prefer short cooking time, although fast cooking is a trait that favors women. Industrially precooked beans could reduce labor of women by nine hours per week, and part of this advantage could be gained genetically. Other traits such as nutritional value may be defined externally by experts but are not desired by farmers. Specific nutritional needs of women and their children are being addressed through biofortification. Women have greater needs for dietary iron that can be addressed with legumes, and iron content of beans is being increased through conventional breeding under the HarvestPlus program. Mothers have enthusiastically adopted orange-fleshed sweet potatoes with pro-vitamin A when informed of the benefits for their children, so information can also affect preferences.

Paper/Poster Abstracts

In conclusion, traits preferred by women may or may not differ from those preferred by men. Furthermore, differential benefits to women may not be associated exclusively with differential preferences. In either case, conscious incorporation of such traits into breeding programs is a matter of persistence on the part of breeders.

Paper Number: 1530

Why Isn't Gender Just about Impact?.

*Jacqueline Ashby**, CGIAR Consortium Office

Abstract not available

Paper Number: 1531

Stress Tolerant Orphan Legumes As a Response to Predicted Climatic Changes.

*Jeremy Tinga Ouedraogo**, Institut de l'Environnement et de Recherches Agricoles

Abstract not available

Paper Number: 1532

Lysimetry; Water Budget.

*Vincent Vadez**, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Abstract not available

Paper Number: 1533

Marama Bean and Domestication.

*Percy Maruwa Chimwamurombe**, University of Namibia

Abstract not available

Paper Number: 1534

Agronomy and Field Trials.

*Patrick Ndakidemi**, Nelson Mandela African Institute of Science and Technology

Abstract not available

Paper Number: 1535

Lablab in Kenya.

*MIRIAM KINYUA**, UNIVERSITY OF ELDORET

Abstract not available

Paper Number: 1536

Genebanks.

*Paul Gepts**, University of California Davis

Abstract not available

Paper Number: 1537

Legume Crops in Arid Regions of India.

*D. Kumar**, CAZRI

Abstract not available

Paper Number: 1538

Symbiotic Nitrogen Fixation and Approaches to Increase Inputs from Nitrogen Fixation in Tropical Grain Legumes.

*Mariangela Hungria**, Embrapa Soja

Farmer's use of inoculants and research aiming at increasing biological nitrogen fixation (BNF) with grain legumes have been inversely related to economic and logistic facilities to get N-fertilizers. In Brazil, about 70% of the N-fertilizers are imported and quoted in foreigner currency; therefore, research aiming at increasing the contribution of BNF to plant's nutrition has been persistent and often very successful in crops with economic value, such as soybean (*Glycine max*), contrarily to countries with low-cost N-fertilizers. In addition, for these legumes cropped in large scale a new horizon has been raised, relying on the global interest in mitigating greenhouse gases emissions (GGE). Unfortunately, in Brazil and in other countries, in family scale farms with low input of fertilizers, although there are promising results of contribution of BNF to important legumes used mainly for food, such as common bean (*Phaseolus vulgaris*), the adoption of the technology has been difficult. The rates of BNF that can be achieved with some legume crops is impressive. The soybean-*Bradyrhizobium* might be considered as the "perfect symbioses", adapted to a variety of edaphoclimatic conditions and reaching rates of 300 kg of N/ha, in addition to about 30 kg N/ha left for the following crop. The estimated economy associated with BNF with soybean in Brazil is of around US\$ 12 billion/year, in addition to the mitigation of about 65 million t of CO₂ equivalent. To achieve this successful story, Brazil has heavily invested in research of BNF with soybean for half a century, and the research continues. Interesting, the best strains selected for the soybean crop in Brazil are also showing an outstanding performance in some field trials in Africa. Therefore, the possibility of transferring technologies related to BNF from southern hemisphere countries as Brazil and Australia to Africa seems feasible and can help to save money and time. On the contrary, it is a paradox that research has proven that it is possible to increase the contribution of BNF in critical crops for food as common bean, by the selection and massive inoculation of elite strains. Data from Brazil has shown that yields of 3,000 kg/ha can be achieved exclusively with BNF, more than three times the national average for this crop. Interesting, excellent results have also been obtained with other crops considered promiscuous in the ability of nodulating with indigenous rhizobia and thus with low probability of responding to inoculation, such as cowpea (*Vigna unguiculata*) and peanut (*Arachis hypogaea*). Especially for the cowpea, the adoption of BNF is impressively increasing among farmers that adopt a high level of technology, but is low among poor farmers with low level of technology. We may thus conclude that the success of BNF relies not only in having good plant and bacterial genotypes, but also in a large effort in educating farmers with low level of technology. Relevant results can also be achieved with the use of other plant-growth promoting rhizobacteria (PGPR), encompassing contributions by a variety of mechanisms including BNF, production of phytohormones, increased stress tolerance, antibiosis against pathogens, among others. The use of *Azospirillum* spp. with the maize crop, and co-inoculation of soybean, common bean and cowpea is increasing considerably in the last five years in Brazil. Finally, we must mention large progresses of the inoculant industry that is now producing inoculants at a very low cost, usually representing less than 0.1% of the establishment of the crop. Globally, in all countries we are perceiving an increasing use of microorganisms, either due to the low cost or to environmental concerns about chemical fertilizers. And Africa can take great advantage of the results obtained in decades of research with microbial inoculants in other countries.

Paper Number: 1539

The Cropping and Farming System Integration and Broader Benefits of Diverse Intercropping and Rotation Systems.

*Bernard Vanlauwe**, IITA

Today, Sustainable Intensification (SI) of smallholder farming systems is high on the agricultural development agenda, especially in rural areas with dense populations. The underlying assumption is that larger yields, produced sustainably, are essential to alleviate rural poverty and natural resource degradation. SI acknowledges the need to increase system productivity while maintaining or enhancing the natural resource base and improving on system resilience. Enabling conditions required to favour uptake of SI at scale cover human, social, and institutional dimensions. Legumes, and especially grain legumes, offer many opportunities to redirect current smallholder farming systems, based on nutrient mining, towards SI. The scale of the contribution of legumes to the yield of subsequent crops goes far beyond what can be simply explained due to inputs from BNF, due to the non-N benefits resulting from suppression of striga and soil borne pests and diseases. This paper will provide an overview of such contributions and put these in the context of specific cropping and farming systems, resource endowments, and other context variables influencing these. Specific attention is given to legume types, their integration in farming systems, soil fertility conditions, and input use. Attention is also given to assessing variability in response and major factors influencing such variability. Lastly, guidelines and recommendations are presented for optimizing the contributions of legumes to the SI of smallholder farming systems, thereby recognizing that ultimately, decisions are taken by individual farming households based on their individual interests, objectives, and needs.

Paper Number: 1540

Setting the Scene - Public-Private Partnerships and Value Addition.

*Jemimah Njuki**, International Livestock Research Institute (ILRI)

Abstract not available

Paper Number: 1541

The Role of Policy in Supporting Value Chain Development and Value Chain Partnership.

*Joyce Mulila-Mitti**, FAO Sub- Regional Office

Abstract not available

Paper Number: 1542

Partnership for Linking Research Outputs to Private Sector Uptake and Enhancing Nutrition.

*Joab Ouma**, Lasting Solutions Ltd

Abstract not available

Paper Number: 1543

How PPP Achieves Faster Food Standards Setting and Legume Products Development and Trade.

*Margaret Lungu**, Government Standards Bureau

Abstract not available

Paper/Poster Abstracts

Paper Number: 1544

The Broader Research Framework for Legumes and How to Build a Partnership to Promote Legumes Research Using a Case of Pulse Innovations in Chickpea.

*Meseret Beyene**, Ethiopian Institute of Agriculture Research

Abstract not available

Paper Number: 1545

Industrial Processor; Partnerships for Linking Research to Product Development for New Pulse Products.

*Joab Ouma**, Lasting Solutions Ltd

Abstract not available

Paper Number: 1546

Research to Support Agribusiness and Investments in Pulses.

*Bill Brown**, University of Saskatchewan, Canada

Abstract not available

Paper Number: 1547

A Zambian Farmer's Perspective on How the PPP Can Work for the Smallholder Pulse Farmer.

*Evelyn Nguleka**, Zambia National Farmers Union

Abstract not available

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