# USAID Feed the Future Innovation Lab for Climate Resilient Cowpea

12 Sept 2013 - 11 Sept 2018

Timothy J. Close
Athens, Greece
14 May 2014



**United States Agency for International Development (USAID)**
**Feed the Future Program Area: High Yielding, Climate-Resilient Legumes**

**Project Title:** **Innovation Lab for Climate Resilient Cowpea**

Lead Institution: *University of California, Riverside*
Dr. Timothy Close (PD); Professor of Genetics & Geneticist
Dr. Philip Roberts (Co-PD); Professor and Chair, Department of Nematology
Dr. Stefano Lonardi (Co-PD); Professor, Department of Computer Sciences

Sub-Awards: *Institut Senegalais Recherches Agricole (ISRA)*
Dr. Ndiaga Cisse, Cowpea Breeder & Director CERAAS

*Institut de l'Environnement et de Recherches Agricoles (INERA)*
Dr. Issa Drabo, Cowpea Breeder
Dr. Jean-Baptiste De La Salle Tignegre, Cowpea Breeder

*Council for Scientific & Industrial Research - Savanna Agricultural Research Institute (CSIR-SARI)*
Dr. Ibrahim Atokple, Breeder

*International Institute of Tropical Agriculture (IITA)*
Dr. Boukar Ousmane, Cowpea Breeder



**Feed the Future Global Hunger and Food Security Research Strategy: Climate Resilience, Nutrition, and Policy**

**Program Area: High-Yielding, Climate Resilient Legumes**

**(1) Advancing the Productivity Frontier**

**This theme focuses on improving food availability**. While better management practices can reduce the prevailing yield gaps in many developing countries, productivity gains necessary to meet future food demand under limited resources and with potentially adverse impacts from climate change require developing new seeds …. To enable such improvements, the FTF research strategy has a focal theme on **breeding and genetics for major crops** and …. This is **expected to increase the yield potential and provide solutions for major production constraints**. To more effectively integrate the use of these technologies among poor farmers, research under this theme includes socio-behavioral and economic factors …… for male and female farmers.



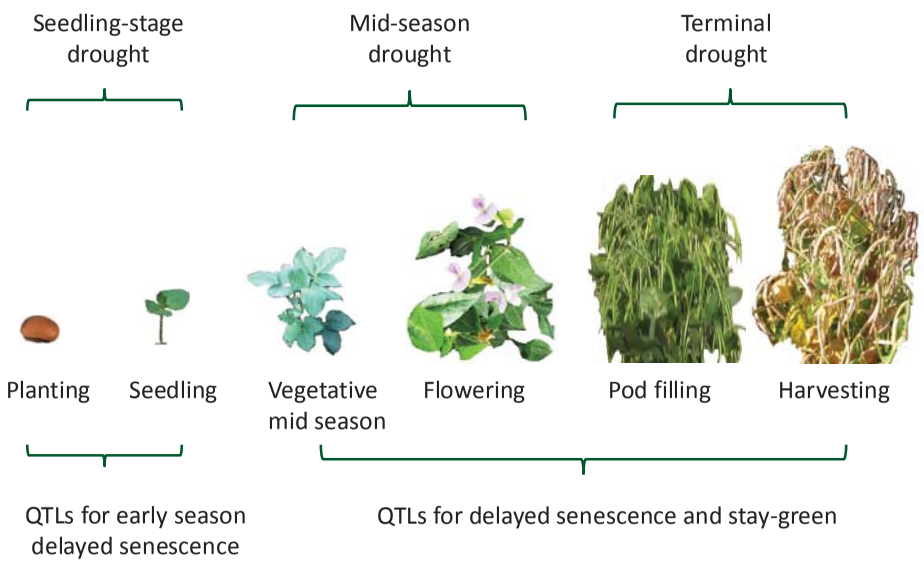
**Feed the Future Global Hunger and Food Security Research Strategy: Climate Resilience, Nutrition, and Policy**

**Program Area: High-Yielding, Climate Resilient Legumes**

**(b) Research Implementation**

The *Feed the Future Research Strategy* used spatial analysis to identify four major production zones where high rates of poverty and malnutrition overlaid areas with high production potential: the Indo-Gangetic plains of South Asia, the **Sudano-Sahelien region of West Africa**, the maize-based, mixed systems of East and Southern Africa, and the Ethiopian Highlands; these same four systems are the subject of the Sustainable Intensification research programs. Outputs from all of these research programs are intended to support USAID Mission and other agriculture, nutrition and food security investments in Feed the Future focus countries (http://www.feedthefuture.gov/countries) and beyond.

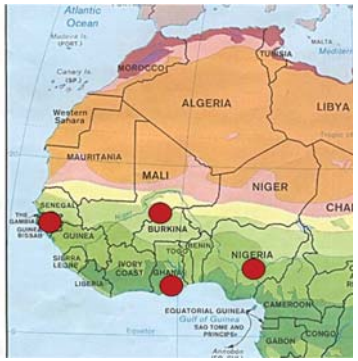
## Drought events across cowpea growing stages






## The Cowpea Team Locations

**Four host country locations in the Sudano-Sahelian region of West Africa. Spanning the main cowpea production agroecologies in this sub-Saharan zone.**




**Location of the UC Riverside Coachella Valley Agricultural Research Station. August planting provides rain-free conditions for drought and heat tolerance phenotyping.**



## Other Abiotic Stress-Related Target Traits

***Macrophomina phaseolina* (ashy stem blight or charcoal rot): drought-stressed plant are prone to infection and disease from this pathogen. Have evidence of resistance QTLs.**

**Heat sensitivity: heat-induced abortion of pollen development resulting in reduced pod set. Have evidence of tolerance QTLs.**



**Objective 1: Foundation Development:** high-density SNP genotyping, marker development and phenotyping for yield, biotic and abiotic stress tolerance and other traits relevant to sub-Saharan Africa

- 20x sequencing of 37 breeding accessions (Jan/Feb 2014)
- SNP discovery & 60k iSelect design (Mar/Apr 2014)
- 60k iSelect available (by Jul/Aug 2014; to be used for LIL also)
- New map from ~1000 biparental & 300 MAGIC RILs (from TL1)
- Genotypes of 200+ germplasm accessions previously phenotyped (in TL1)
- Baseline genotypes of breeders' favorites (intersects LIL interests)
- Emphasizing *Macrophomina* resistance, drought tolerance (flowering, terminal), heat tolerance (reproductive), seed quality & yield

**Objective 2: Training:** Workshops and support of West African breeders in the use of markers to accelerate breeding

- Annual workshop (Mar 2014 at UC Riverside)
- Continuous support of breeders (years 1-5)
- Student training (years 1-5)

**Objective 3: Implementation:** Deploy new marker knowledge for production of improved cowpea seed for farmer evaluation in sub-Saharan Africa

- Throughout the life of the project

## Cowpea MAGIC Parents – yield, diversity, traits

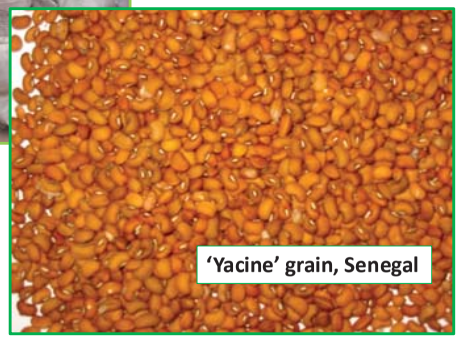
| | | | High Yielding Under Drought in: | | | | |
|---|---|---|---|---|---|---|---|
| Genotype | Source | Diversity Group | Senegal | Burkina Faso | Mozambique | Nigeria | Key Traits |
| CB27 | UCR | A | | | Yes | | Heat tolerance |
| IT00K-1263 | IITA | F | | | Yes | Yes | Striga (races 1,2,3,4,5) resistance |
| IT82E-18 | IITA | B | | | Yes | | Broadly adapted, high yield |
| IT84S-2049 | IITA | C | | Yes | | | Aphid, bacterial blight, CAbMV Root-knot nematode resistance |
| IT84S-2246 | IITA | G | | Yes | Yes | | Aphid, bacterial blight, CAbMV Root-knot nematode resistance |
| IT89KD-288 | IITA | D | | Yes | | Yes | *Yield, grain quality* |
| IT93K-503-1 | IITA | H | Yes | | | | Drought tolerance, *Macrophomina*, *Striga* (races 1,3,4) resistances |
| SuVita 2 | INERA | E | Yes | Yes | Yes | | *Striga* (races 1,2,4) resistant, drought tolerance, high yield |



## Cowpea in sub-Saharan Africa


Forage is highly valued for livestock feed

Grain vitally important in human diet






## 60k iSelect Infinium Assay

April 2014

iCommunity NEWSLETTER

### Breeding Climate-Resilient Cowpea for Improved Food Security in West Africa

Illumina high-density genotyping expected to accelerate marker-assisted breeding.

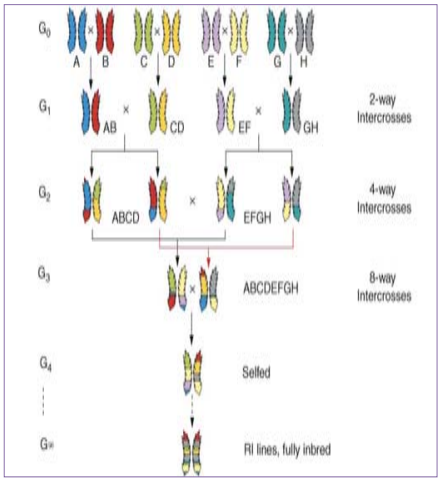
Recognizing that its technology could play a critical role in alleviating global hunger, malnutrition, and poverty, Illumina created the Agricultural Greater Good initiative. Each year, Illumina awards Greater Good grants to agricultural research organizations that are focused on identifying and breeding plants and animals that will increase the sustainability, productivity, and nutritional density of crop and livestock species. Under the grants, Illumina sequencing and genotyping reagents are provided free of charge.

UC RIVERSIDE UNIVERSITY OF CALIFORNIA 2014 Illumina Greater Good Initiative Award Winner

**The Illumina 2014 Agricultural Greater Good Initiative Award was given to the cowpea team, stimulating a consortium and reducing the cost of an iSelect SNP genotyping assay so that we can afford a 60,000 BeadAssay design.**



## MAGIC Population Design




Cavanaugh et al. 2008. From mutations to MAGIC: resources for gene discovery, validation and delivery in crop plants. Curr Opin Plant Biol 11:215-221.

### Cowpea MAGIC

G2-G3: ~330 pair crosses made, Spring & Fall 2011 (TL1)

G4 and beyond: Single seed descent of F2s 2012-2014 (TL1)

- **Most now at F8 seed**
- **Planting May 2014 to advance stragglers to F6, F7, F8 and carry F8 to F9.**

# Cowpea-Common Bean Synteny

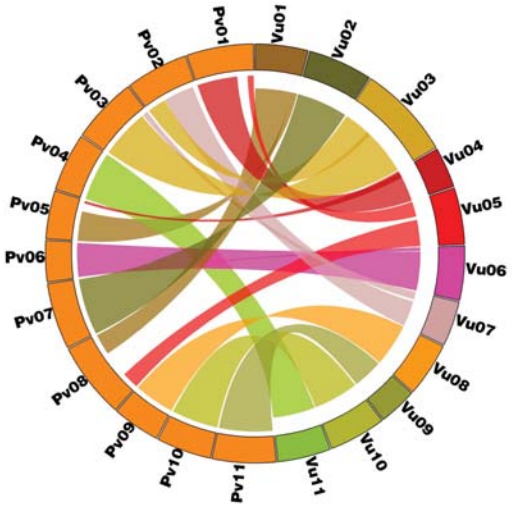



Image from Mitch Lucas, UC Riverside, 2012

**Cowpea Genetic Map**

- 11 RIL populations
  - 1117 individuals
- 1091 EST-derived SNPs
- 11 linkage groups

**Common Bean Genome**

- Phytozome *P. vulgaris* v1.0
  - 11 pseudomolecules

**Relationships**

- Best BLAST *P. vulgaris* gene model for each *V. unguiculata* SNP source sequence
- Illustrated using Circos
- 6 of 11 LGs have complete synteny



# Phylogeny of African Cowpea Landraces

**305 landraces (from IITA)**

**SNP genotyping**

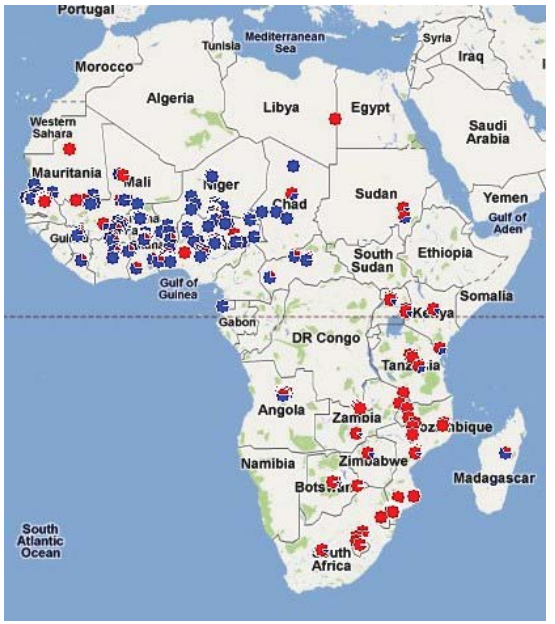
SNPs MAF >0.1

**STRUCTURE**:

Two predominant genetic groups:

Southeastern Africa: Kenya, Tanzania, Mozambique, Zimbabwe, Botswana, South Africa

Western Africa: Senegal, Cameroon, Burkina Faso, Niger, Mali, Chad, Ivory Coast, Ghana, Benin




Huynh et al. (2013) The Plant Genome 6: doi:10.3835/plantgenome2013.03.0005



# SNP design summary

56,719 SNPs in design of 60,000 BeadAssays

- ~39,500 target cowpea sequences matching 20,788 *P. vulgaris* gene models
- ~19,300 target other cowpea sequences genome-wide
- 1163 are recycled from GoldenGate Assay (all genic)
- 60 target plastid or mitochondrial genome

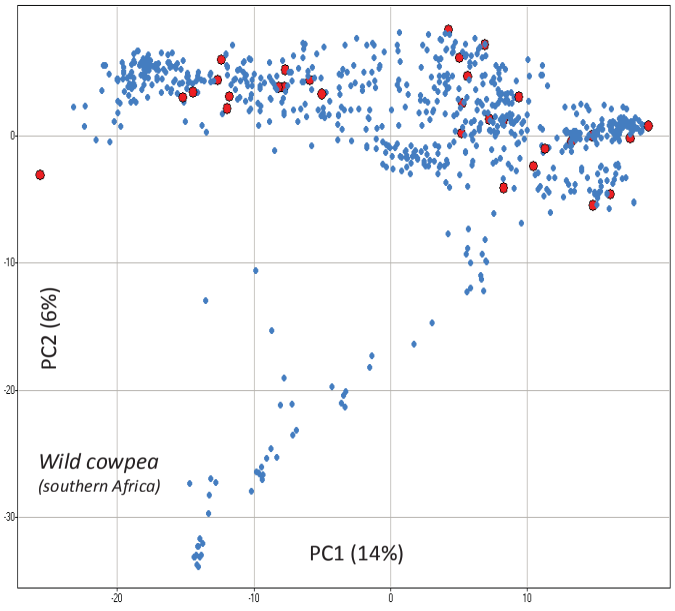
# Intended Genotyping Workflow

- Tissue sent to UCR in ziplock bags with desiccant
- DNA extracted at UCR, sent to local genotyping provider
- SNP data transferred by FTP to UCR
- SNP data imported into GenomeStudio, exported as Excel files:
  - Flapjack for visualization
  - ICI Mapping for QTLs
  - OPTIMAS to guide crosses for QTL pyramiding (foreground)
  - Backcross Selector also to guide parent and progeny selection (background)



# SNP Ascertainment

*Cowpea landraces (mainly **Southeast Africa,** also Asia, North America)*




*Cowpea landraces (mainly **West Africa**, also Central and North Africa)*

## By end of 2014, we expect to have the following:

Genotype-informed view of breeder's favorites

- Initial 48 tissue samples sent from each host country partner to UCR in March 2014, more are possible
  - Will clarify extent of variability within lines
  - Will confirm or correct pedigree information
- Increased seed from favorite individuals sampled for genotyping
- New phenotype data from breeders' favorites

**Each partner has an allocation of 192 "favorites" for genotyping and 800 other samples to support breeding objectives during the life of the project**



# Materials Needed for Tissue Collection for SNP Genotyping

2 Silica gel packs


Plastic zip lock bag with cowpea variety name and the date collected



**U California, Riverside**

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**African Breeding Partners**

**ISRA, Senegal**
Ndiaga Cisse, Mohammadou Moussa Diangar

**INERA, Burkina Faso**
Issa Drabo, Jean-Baptiste Tignegre, Joseph Batieno

**IITA, Nigeria**
Ousman Boukar, Christian Fatokun

**CSIR-SARI, Ghana**
Ibrahim Atokple, Francis Kusi

NSF

USDA United States Department of Agriculture National Institute of Food and Agriculture

Generation A CGIAR Challenge Programme

USAID FROM THE AMERICAN PEOPLE



# Drying and Shipping the leaves

- Package in the zip lock bag with 2 silica gel packs
- Make sure to seal the bag
- Leaf tissue will dry within a few days before or during shipment