The Phaseolus USAID Climate Resilience Project

Feed the Future Global Hunger and Food Security Research Strategy

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North Dakota State University

Legume Innovation Labs
Global Grain Legume Researchers Meeting
Improving Agriculture and Nutrition through Grain Legumes
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An Integrated Program to Accelerate Breeding of Resilient, More Productive Beans for Smallholder Farmers

Principal Investigator
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Co-Principal Investigators

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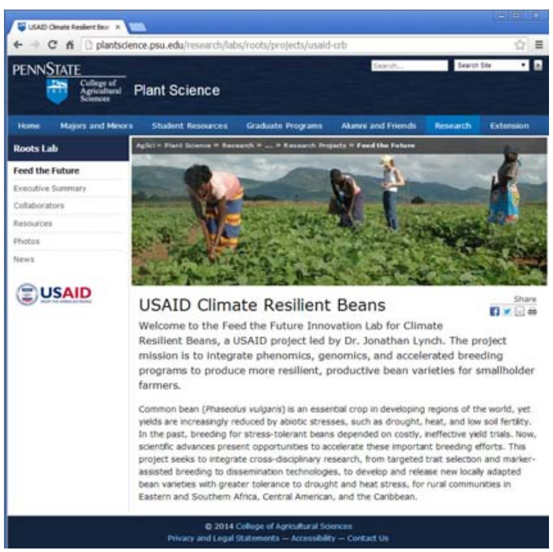
- Jill Findeis: University of Missouri
- Phil McClean: North Dakota State University
- Magalhaes Miguel: Agricultural Research Institute of Mozambique (IIAM)
- Phil Miklas: USDA-ARS-WA
- Timothy Porch: USDA-ARS-PR
- Juan Carlos Rosas: Zamorano University
- Jeffrey White: USDA-ARS-AZ

USAID Research Program
Global Hunger and Food Security Research Strategy:
Climate Resilience, Nutrition, and Policy

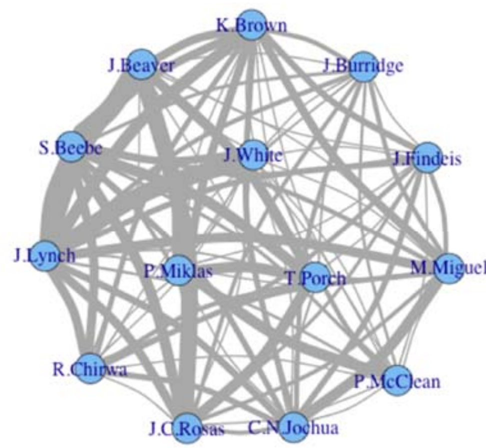
Who We Are, Where to Find Us

http://plantscience.psu.edu/research/labs/roots/projects/usaid-crb



Highly Integrated Project Team

Many Successful Past Collaborations



Project Activities
Four Research Areas

Table 1. Timeline for task completion for an integrated program to accelerate breeding of resilient, more productive beans for smallholder farmers (specific collaborations highlighted)

Program Activity	2013 Sep	2014 Mar	 Sep	2015 Mar	 Sep	2016 Mar	 Sep	2017 Mar	 Sep	2018 Mar
Phenomics (Lynch, Porch, White. Miguel, see Table 5)										
Profile bean germplasm for validated tolerance	X	X	X	X	X	X	X	X	X	
Identify and validate novel tolerance traits	X	X	X	X	X					
Develop high-throughput phenotyping platforms		X	X	X	X	X	X			
Genomics (McClean, see Table 6)										
Genotyping	X	X	X	X	X	X	X	X	X	
Association mapping	X	X	X	X	X	X	X	X	X	
QTL and in-depth RHL analysis	X	X	X	X	X	X	X	X		
Accelerated Breeding (Beebe, Miklas, Porch, Jochua, Carlos, see Table 2)										
BASE Trials, Test lines for adaptation and abiotic	X	X	X	X	X	X	X	X	X	
Select parentals for abiotic stress breeding	X	X	X	X	X	X				
Breeding for abiotic stress tolerance		X	X	X	X	X	X	X	X	X
Participatory selection of breeding lines, HN&MZ					X	X	X	X	X	X
Release new varieties									X	X
Social Impact (Findeis, see Table 7)										
PVS at sites; adoption constraints	X	X	X	X	X	X	X	X	X	
Social network analysis, dissemination strategies	X	X	X	X	X	X	X	X	X	
Educational Materials	X	X	X	X	X	X	X	X	X	
Project Management										
Semiannual reviews	X	X	X	X	X	X	X	X	X	X
Annual project meetings	X		X		X		X		X	

Phenomics
ManyTraits Under Evaluation

Table 3. Phenotyping methods to be developed and employed.

Stress/Phase	Stage	Trait	Method	Status
Heat				
Vegetative	Pre / post flower	Canopy temp: Macro Arrays	IR thermometers	Developed
	Pre / post flower	PSI (Plant stress index)	IR thermo & multispectral sensor	In development
Reproductive	Pre-anthesis	Bud abortion	1-9 scale	In development
	Anthesis	Pollen viability	Peroxidase, MTT test; lab vs.	In development
	Early pod fill	Pin bean formation	1-9 scale	In development
	Mid pod fill	Seed abortion	1-9 scale	In development
	Late podfill	Pod fill	1-9 scale	Developed
	Harvest	Variability in seed size,	Image analysis	In development
Drought				
Vegetative	Pre / post flower	Canopy temp: Macro Arrays	IR thermometers	Developed
	Pre / post flower	PSI (Plant stress index)	IR thermo & multispectral sensor	In development
	Germination	Basal root whorl number	Roll-ups visual inspection	Developed
	Germination	Basal root growth angle	Roll-ups visual inspection	Developed
	Germination	Basal root number	Roll-ups visual inspection	Developed
	Anthesis	Basal root growth angle	field excavation (shovelomics)	Developed
	Anthesis	Basal root whorl number	field excavation (shovelomics)	Developed
	Anthesis	Adventitious rooting	field excavation (shovelomics)	Developed
	Anthesis	Taproot branching	field excavation (shovelomics)	in development
Reproductive	Pre-anthesis	Bud abortion	1-9 scale	In development
	Anthesis	Pollen viability	Peroxidase, MTT test; lab vs.	In development
	Early pod fill	Pin bean formation	1-9 scale	In development
	Mid pod fill	Seed abortion	1-9 scale	In development
	Late podfill	Pod fill	1-9 scale	Developed
	Harvest	Variability in seed size, shape	Image analysis	In development

Phenomics
Tools for Field Evaluation

Bar for turning cart

Data collection cart built in Mayaguez, Puerto Rico. The design of the field collection cart includes a bar for turning the wheels of two bicycles to facilitate movement through the field. Computer, sensor, and datalogger equipment will be mounted on the cart for the collection of field data (as per White and Conley, 2013).

Field Phenomics

USDA ARS
Maricopa, Arizona

Methods development:
- Vehicles for deploying sensors
- Sensors for abiotic stress tolerance
  - GPS: sub-meter positioning
  - Reflectance: leaf area development
  - Infrared thermometry: plant stress
- Deployment in bean trials in June
- Training for bean researchers in June

GPS

Reflectance sensors

Infrared thermometers

Phenomics

Root Traits

Careful evaluation of root phenotypes in multiple environments

Figure 1. Shallow vs. deep root architecture caused by genotypic variation in the growth angle of basal roots (BRGA) of bean plants grown in the field in Honduras. This image was gathered via 'shovelomics' by which numerous architectural and morphological root traits may be visually scored in the field at an average rate of 2 min per plot.

Accelerated Breeding

Goal: Released Lines

Table 2. Andean and Mesoamerican germplasm development using two breeding strategies: single crosses (1) and complex crosses (2). Complex cross activities will be one generation behind the simple cross activities.

Generation (1)	Location	Completion Date	Activity 1. Single crosses; 2. Complex crosses	Notes
Parental	All	Y1; 3/13	1. Hybridization for simple cross populations	
F_1	All	Y1; 9/13	1. Gen. Advance; 2. Hybridization for 3-way, 4-way crosses	
F_2	All	Y1; 9/13	1. Gen. Advance, Bulk 2. Gen. Advance (F1)	
$F_{2:3}$	All	Y2; 3/14	1. Gen. Advance, Bulk 2. Gen. Advance, Bulk (F2)	
$F_{2:4}$	All	Y2; 9/14	1. Gen. Advance, Bulk; Select by sd. class 2. Gen. Advance, Bulk (F2:3)	
F_5	1. HN, MZ	Y3; 3/15	1. Single plant selection under stress 2. Gen. Advance, Bulk (F2:4) All	1. $F_{2:4}$ seed to HN, MZ
$F_{5:6}$; $F_{5:7}$	1. PR, SA	Y3; 9/15	1. Incr. F5:6; F5:7 under non-stress (HN, MZ) 2. Single plant selection under stress in HN, MZ (F5)	1. Backup F_5 seed in PR, SA
$F_{5:7}$	1. HN, MZ	Y4; 3/16	1. Participant selection on-station 2. Increase F5:6; F5:7 under non-stress (PR, SA)	
$F_{5:8}$	1. All non US	Y4; 9/16	1. Participant selection on-farm/station 2. Participant selection on-station (F5:7) HN, MZ	1. BASE-2
$F_{5:8}$	1. All non US	Y5; 3/17	1. Selection of lines for release; Increase (All) 2. Participant selection on-farm/station (F5:8)	1. Regional trials 2. Base-2
$F_{5:10}$	2. All non US	Y5; 9/17	2. Selection of lines for release; Increase (All)	2. Regional trials

Accelerated Breeding

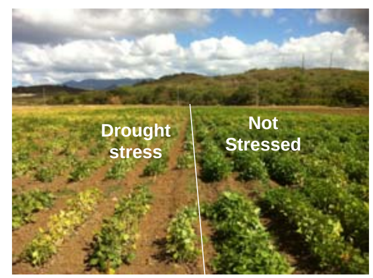
Advancing Breeding Populations

Generation advance of F_2 populations (in center) for the generation of bulked Andean and Mesoamerican breeding populations for abiotic stress tolerance in Isabela, Puerto Rico in February, 2014.

Accelerated Breeding

Line Screening for Stress Tolerance

ADP **under** ***Drought Stress*** **(Left side)** ***and Non-stress*** **conditions in Juana Diaz, Puerto Rico in February, 2014.**



BASE trial **planted under** ***Drought Stress*** **in Juana Diaz, Puerto Rico in March, 2014.**

Accelerated Breeding

Screening in Target Locations

ADP in Mozambique

ADP under P stress in Mozambique

The Climate Changes

Pest Problems Changes

More Rain,
More foliar diseases

Reduced Rain
More Pests

And new problems
In new locations

Accelerated Breeding

Mining Tepary Bean (P. acutifolius) Alleles

Beneficial Phenotypes

- Rapid root growth
- Long thin roots
- Stomatal control of water efficiency
- Deceive transition from vegetative to reproductive growth
- Efficient mobilization of nutrients to seeds
- Tolerates high temperature

Accelerated Breeding

Mining Tepary Bean (P. acutifolius) Alleles

Differences in pod formation under drought conditions

Accelerated Breeding

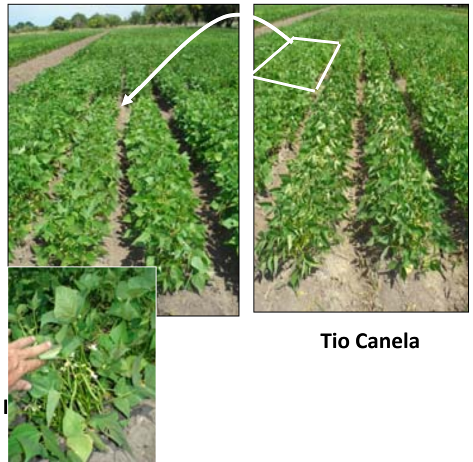
Congruity Backcrossing P. acutifolius

(*P. vulgaris* x
P. acutifolius)

x

P.v. x *P.a.*

P.v. x *P.a.*

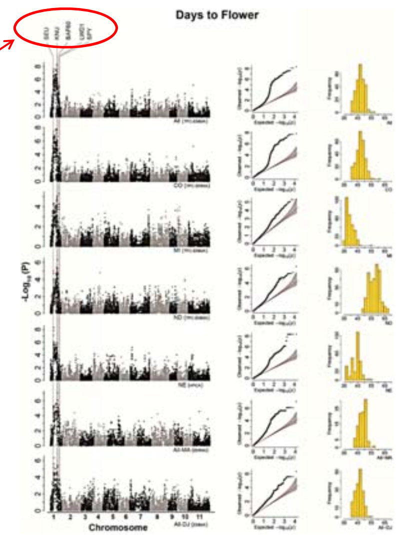


Tio Canela

Genomics

Genome Wide Association Studies

Finding target genes



Phenotypic Variance (GxE)

Social Sciences

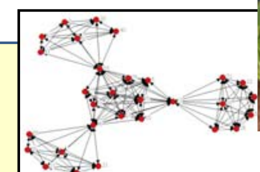
Assess what is now known about consumption trait preferences – common bean in Mozambique

- **Mixed method approach in rural experimental sites – stated and revealed preference elicitation focusing on consumption traits**
- **Urban consumer trait preference assessment**
- **Training of IIAM social scientists with CoPI Rosas' team at Zamorano**

College of Agriculture, Food and Natural Resources

Social Sciences

Develop, implement and test a promotional campaign targeting common bean (Agroecological Innovation Campaign)



- **Expand village network simulations developed in previous USAID DGP CRSP and McKnight projects**
- **Missouri School of Journalism capstone course will hold competition to design common bean campaign using simulations**
- **Winning design will be adapted, implemented and tested for effectiveness**

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Social Sciences

Develop and pilot educational materials targeting smallholder women (library)

Goal – develop and test educational materials to help women prepare for climate change

- **Increase knowledge of bean varieties suitable for varying agroecological-climatic conditions**
- **Increase knowledge of bean-based farming systems that specifically fit needs/preferences of women**
- **Test digital vs traditional formats**

College of Agriculture, Food and Natural Resources

CTSI Clinical and Translational Science Institute

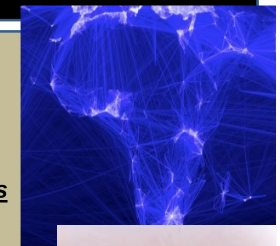
THE McKNIGHT FOUNDATION

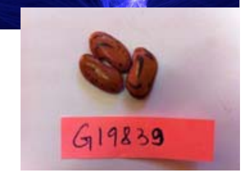
USAID

Social Sciences

FOCUS ON:

- **Production & consumption trait preferences by:**
  - ***- gender (<u>women largely produce)</u>***
  - ***- children/youth (<u>critical protein need)</u>***
  - ***- rural-urban (<u>where produced VERSUS where population will grow the most in absolute terms</u>***
- ***Knowledge diffusion – tools will be there (eg, mobile phones, apps, etc.) <u>but is agricultural knowledge now well organized? Sensitive to needs and preferences of women/children? And how to rapidly push through pipeline for uptake?</u>***
- ***<u>Next generation engagement</u> – MU capstone students***
- ***<u>Capacity building</u> of IIAM science-social science team for sustainability***





USAID FROM THE AMERICAN PEOPLE

Communicating and Training

Human Resource Improvement

Luis Madepule and Jim Burridge visiting with Mozambique's Vice Minister of Agriculture

Luis Madepule measuring available soil phosphorus at the Sussundenga Research Station.

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Ultimate Deliverables

Seeds in the Hands of Target Population

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