


Feed the Future Innovation Lab for Collaborative Research on Grain Legumes

SO1.A1: Genetic Improvement of Middle-American Climbing Beans in Guatemala.

Project Director: Juan M. Osorno
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Project Participants

- NDSU:
  - Juan M. Osorno
  - Phil McClean
- ICTA:
  - Julio C. Villatoro
  - Fernando Aldana
  - Karla Ponciano
  - Julio Martinez
  - Edgardo Carrilllo

41 years of ICTA

"The Climbing Bean Team"


Common Bean

Essential Food Security Crop in Poor Countries

	Food Source			
	Beans		Maize	
	% protein/capita/ day	% kcal/capita/ day	% protein/capita/ day	% kcal/capita/ day
East Africa				
Burundi	35.9	15.0	11.8	12.0
Rwanda	***31.6***	***12.3***	***6.9***	***6.6***
Tanzania	***15.8***	***6.1***	***22.5***	***24.3***
Uganda	***13.6***	***4.5***	***9.1***	***8.4***
Kenya	***11.5***	***5.0***	***30.3***	***32.1***
West Africa				
Benin	12.7	4.9	18.8	17.6
Cameroon	11.6	4.4	12.8	12.4
Togo	11.4	4.1	28.9	25.6
Angola	9.5	3.3	19.4	16.4
Central America				
Nicaragua	***21.0***	***8.6***	***24.7***	***25.3***
El Salvador	12.9	5.5	24.9	26.6
Guatemala	***8.2***	***3.4***	***34.4***	***36.1***
Honduras	***7.9***	***3.0***	***29.0***	***27.4***
Costa Rica	7.5	3.0	3.2	3.2
Mexico	6.0	3.2	29.3	32.5
Belize	5.8	2.2	8.4	9.4

FTF Countries

Slide from P. McClean

Guatemala

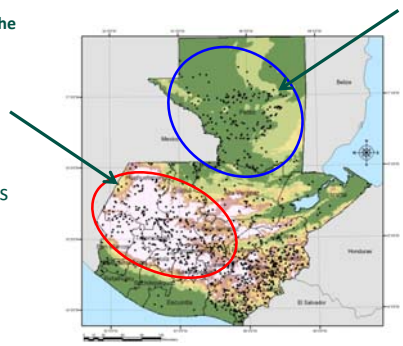
Most Populated (15.4 million) and Poorest Country in Central America

40% of Population: 0-14 years old
55% of Population: 15-64 years old

65% of Population lives in the highlands

Western Highlands
- 26% Extreme poor
- 47% Poor
- 18% Access to assets

67% Stunted
Poverty density high
- 74-270 Poor/km^2



Northern Lowlands
- 32% Extreme poor
- 46% Poor
- 30% Access to assets

49% Stunted
Poverty density low
- 7-83 Poor/km^2

Adopted from: USAID: Guatemala Strategic Review, Feed the Future, October, 2010

Slide from P. McClean

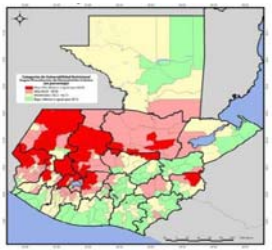
Guatemala

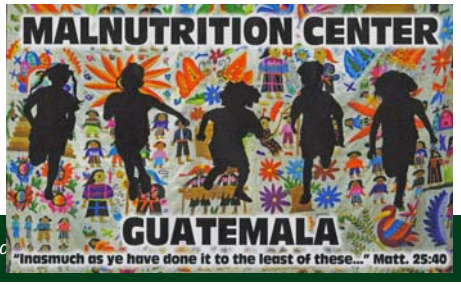
Poverty and Malnutrition

Gross National Income
- US$2,740
- 53% in poverty

Chronic Malnutrition
- 4th highest in world

Climate Challenges
- Drought and flooding





Slide from P. McClean

Guatemala

Poverty and Malnutrition in Rural Regions

	Oct - Nov	Dec - Feb	March	April - Sept
Milpa cycle	Harvest	Fallow	Planting	Growth
Malnutrition	Moderate to Low	Low	Low	*Moderate to High*
Bean availability	Moderate	Low	None	None

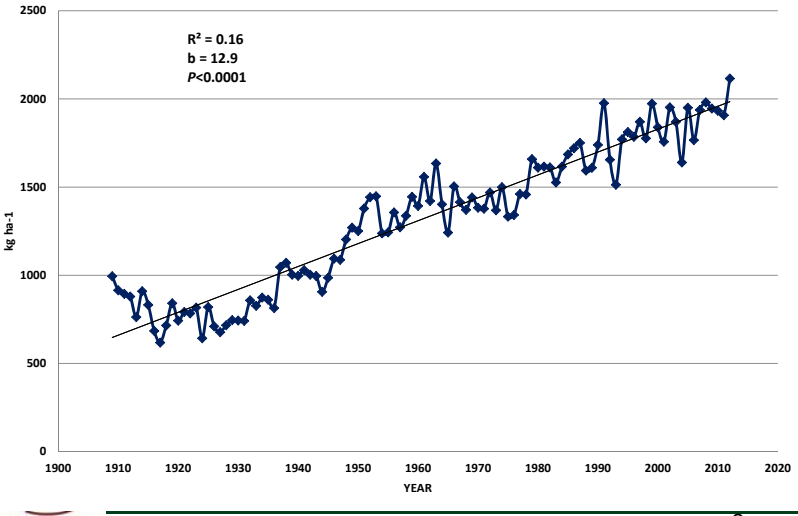
Beans
- A valuable cash crop during the year

Diet
- Unbalanced: 95% maize, 5% beans
- Optimum: 75% maize, 25% beans

Adage
- "Tortillas and salt is the only thing we need."

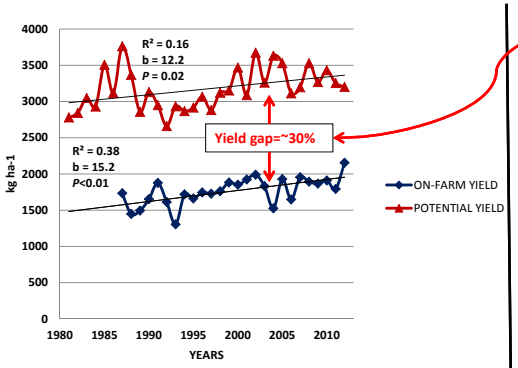
Slide from P. McClean

U.S. On-Farm Yields Across all Market Classes (1910-2012)



Source: Vandemark et al., 2014

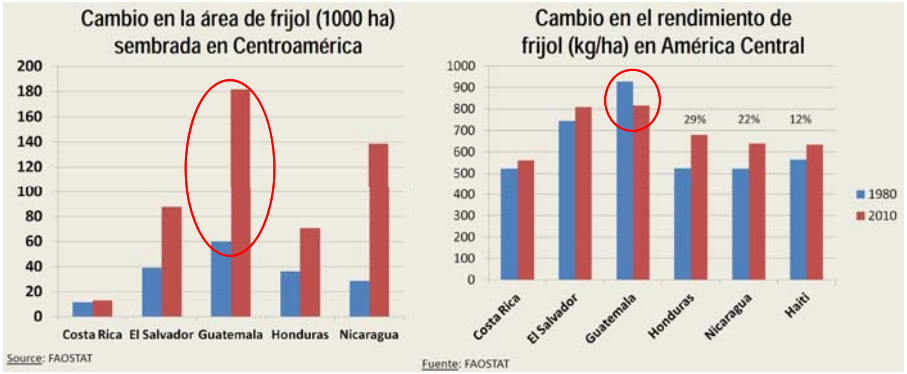
Seed Yield Gap
U.S. vs. Developing Regions



Pinto Seed Yields (1980-2012)
Source: Vandemark et al., 2014

Region	Avg. Yield (2008-10 avg.)	Potential Yield	Yield Gap	
		kg ha^{-1}		%
Latin America and Caribbean	856	1800	944	52
East and South Africa	675	2020	1345	67
West and Central Africa	840	2125	1285	60

Source: CGIAR Collaborative Research Program for Grain Legumes (CRP 3.5 - 2012)



Slides made by J. Beaver

Milpa Cropping System
Beans Go To Local Market For Cash





Bolonillo bean
- High value
- $1.50/lb
- Nov 2013

Slide from P. McClean

Common Bean
Milpa Cropping System in Central America

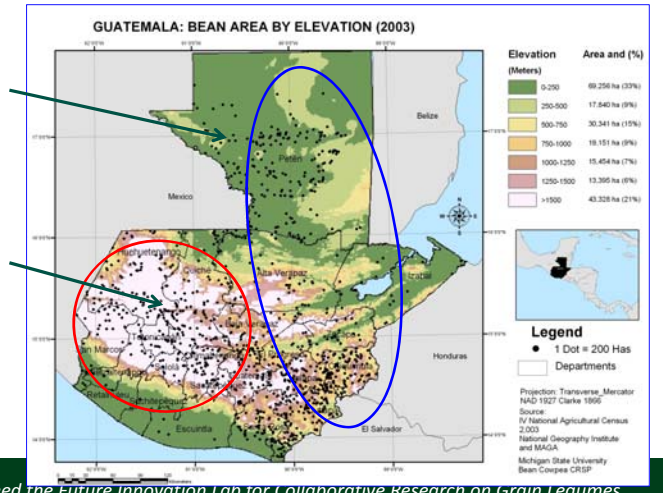
Milpa System
- Beans and maize intercropping
  - Component of old cropping systems
    - Mexico and Central America
  - Still used by poor farmers in the region
    - Major source of protein, calories
  - Two major milpa systems:
    - Direct: maize and beans planted simultaneously
    - Relay: Maize planted first, then beans few weeks later.
  - Other crops such as pumpking, peas, and faba beans also included within the Milpa system in some cases.

Milpa Cropping System
Prevalent Throughout the Highlands

Case: Guatemala
Bean Production Regions

Lowlands
- Monoculture

Highlands
- Milpa



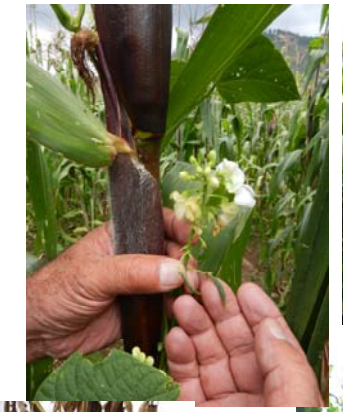
Guatemala Crop Production
Rural Demographics

Farm Size
- 85% of farmers
  - 1 – 10 hectares
  - Milpa highlands
- 10% of farmers
  - Less than 1 hectare
  - Milpa highlands
- 2% of farmers
  - Greater than 10 hectares
  - Lowland monoculture

10 Year Rule
- If land is occupied and utilized for 10 years
  - Occupants own the land
  - Fosters economic development

Climbing beans in Guatemala

- All type IV growth habit: aggressive climbers
- Mostly medium-size black beans
  - Bolonillos
- Other Phaseolus species
  - *P. coccineus* L.
  - *P. polyanthus* L.
- Planting to harvest: ~180 days!
- Susceptible to several fungal diseases and insects
- Worldwide: less breeding/improvement efforts and resources devoted to climbing beans vs. bush-type beans
- No good regional socio-economic data about seed-type preferences, varieties grown, production systems (relay vs direct),household consumption vs sale, etc.


ICTA Germplasm Collection

- 600 climbing bean accessions
  - 3 Phaseolus species
  - Unique group with wide genetic diversity
  - S. Beebe et al. (2000) proposed a "Guatemala race"
- A. Orellana et al. (2006): Morpho/agronomic characterization.
- K. Ponciano et al. (2009):
  - Molecular characterization with SSR markers
  - Results showed that ½ of the collection may be duplicates.
  - Proposed a core collection of 300 accessions.

Objectives

- Development of germplasm with improved disease resistance and agronomic performance.
- Characterization of the genetic diversity of this unique set of germplasm.
- A better understanding of the current socio-economic status and needs of bean production within the context of intercropping systems in the region.
- Capacity building: training the next generation of plant breeders for Guatemala and establishing a long-term breeding plan to increase the productivity of climbing bean in the region.

Objective 1: Germplasm Development

- 25 accessions with traits of interest.
  - 10 promising accessions based on agronomic performance
    - Field testing at 10 locations (milpa)
    - 2-3 best accessions will be tested in farmer's fields at 3 locations during years 2 and 3.
  - Evaluation of "Bolonillo-Texel" in farmer's fields and 10 locations over 2-3 years.
  - First crossing block among promising accessions
    - F_3-F_4 generation in 3 years?
  - Agronomic evaluation under different production systems.
  - Release of selected germplasm

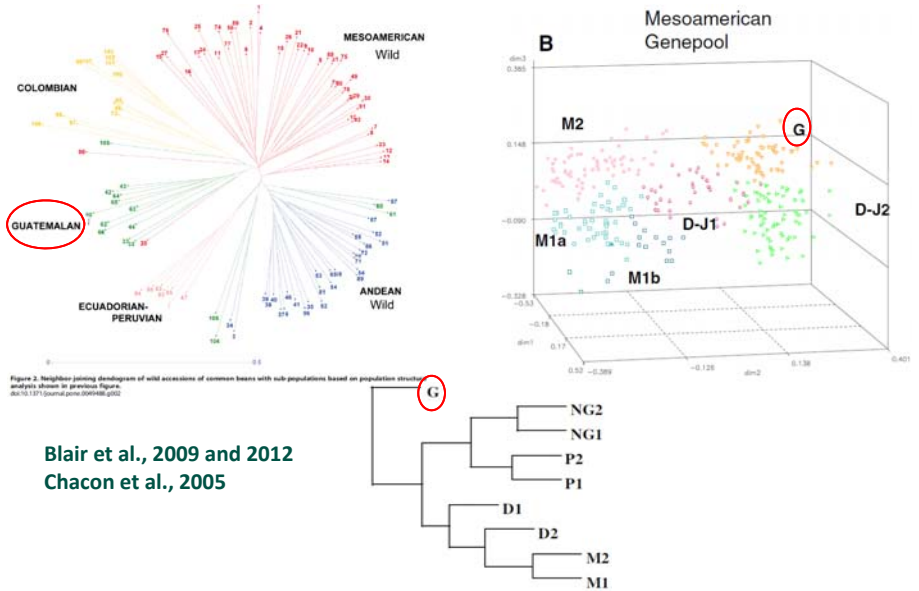
Untapped source of genes!

Target Breeding Traits

- Seed Yield and pod load distribution
- Disease/insect resistance
  - Ascochyta
  - Rust
  - Anthracnose
  - BCMV
  - Mexican weevil (*Apion* sp.)
- Climbing aggressiveness (direct Milpa system)
- Earliness

Objective 2: Characterization of the Genetic Diversity

- Molecular characterization of the core 300 accessions using the 6k SNP chip (BeanCAP).
  - Higher genetic resolution
  - Highly stable
  - Known physical position in the genome
- Analysis of genetic diversity and structure (population genomics)
- Assessment of intra-accessions variability using the 10 selected accessions
- Disease evaluation in the field (natural pressure) and also in greenhouse:
  - Rust (NDSU/UNL)
  - Anthracnose (NDSU)
  - Ascochyta (NDSU)
  - BCMV (UPR)
  - Data will be used for Genome-Wide Association Studies (GWAS).



Blair et al., 2009 and 2012
Chacon et al., 2005

Objective 3: Socio-economic Situation of Climbing Bean Production in the Guatemalan Highlands

- No data about the current status of the bean crop in regards to household consumption, common and preferred seed types produced, agronomic practices, among many other factors.
- Even more important, there is no information about the current needs in regards to bean production.
- Julio Martinez: rural social economist at ICTA will lead this work.
  - Phase 1: Grower's survey and data analysis
  - Phase 2: Grower acceptability of new varieties/technology
- Collaboration/advising from Mywish Maredia

Objective 4: Capacity Building and Long-Term Plan

- ICTA needs M.S. and Ph.D. training for all crops.
  - "Seed program" already in place to identify outstanding young individuals
  - Two graduate students at NDSU trained in plant breeding and plant pathology (2 potential candidates)
  - Degree training at NDSU is less expensive than most U.S. universities (efficient use of funds)
- Technical workshop at NDSU (3rd year)
  - ICTA personnel to visit NDSU
  - Workshop to design a medium and long-term plan for bean breeding efforts in Guatemala
- Informal training during visits to ICTA

Feed the Future Innovation Lab for Collaborative Research on Grain Legumes

Collaborators/Partners

- SO1.A4 project lead by Jim Beaver
- Nutrifrijol project lead by Luis Flores
- USAID Mission in Guatemala
- Juan Carlos Rosas – EAP-Honduras
- Jim Steadman – UNL
- Jim Kelly - MSU
- Steve Beebe - CIAT

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Expected Outputs

- The development and release of improved climbing beans with better agronomic performance.
- A better understanding of the organization of the genetic diversity within this unique set of germplasm.
- Identification of genomic regions associated with traits of agronomic/economic importance.
- An information database of the current market situation and production needs of climbing beans in the highlands of Guatemala.
- Training of the next generation of plant breeders.
- Establishment of a long-term breeding approach.

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