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Project Participants

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  - Phil McClean

- ICTA:
  - Julio C. Villatoro
  - Fernando Aldana
  - Karla Ponciano
  - Julio Martinez
  - Edgardo Carrillo

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Common Bean
Essential Food Security Crop in Poor Countries

<table>
<thead>
<tr>
<th>Food Source</th>
<th>Beans</th>
<th>Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% protein/capita/day</td>
<td>% kcal/capita/day</td>
</tr>
<tr>
<td>East Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burundi</td>
<td>35.9</td>
<td>15.0</td>
</tr>
<tr>
<td>Rwanda</td>
<td>31.6</td>
<td>12.3</td>
</tr>
<tr>
<td>Tanzania</td>
<td>15.8</td>
<td>6.1</td>
</tr>
<tr>
<td>Uganda</td>
<td>15.6</td>
<td>4.5</td>
</tr>
<tr>
<td>Kenya</td>
<td>12.5</td>
<td>5.0</td>
</tr>
<tr>
<td>West Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benin</td>
<td>12.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Cameroon</td>
<td>11.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Togo</td>
<td>11.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Angola</td>
<td>9.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Central America</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nicaragua</td>
<td>21.0</td>
<td>8.6</td>
</tr>
<tr>
<td>El Salvador</td>
<td>12.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Guatemala</td>
<td>8.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Honduras</td>
<td>7.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>7.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Mexico</td>
<td>6.0</td>
<td>3.2</td>
</tr>
<tr>
<td>Bolivia</td>
<td>5.8</td>
<td>3.3</td>
</tr>
</tbody>
</table>

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"The Climbing Bean Team"
**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 low
- 74-270 Poor/km²

**Northern Lowlands**
- 32% Extreme poor
- 46% Poor
- 30% Access to assets
- 49% Stunted
- Poverty density high
- 7-83 Poor/km²

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

**Slide from P. McClean**

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**Guatemala**

**Poverty and Malnutrition**

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

- Chronic Malnutrition
  - 4th highest in world
  - Climate Challenges
  - Drought and flooding

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**Guatemala**

**Poverty and Malnutrition in Rural Regions**

<table>
<thead>
<tr>
<th>Milpa cycle</th>
<th>Oct - Nov</th>
<th>Dec - Feb</th>
<th>March</th>
<th>April - Sept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malnutrition</td>
<td>Harvest</td>
<td>Fallow</td>
<td>Planting</td>
<td>Growth</td>
</tr>
<tr>
<td>Bean availability</td>
<td>Moderate to Low</td>
<td>Low</td>
<td>Low</td>
<td>Moderate to High</td>
</tr>
</tbody>
</table>

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.”

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

- R² = 0.16
- b = 12.9
- P<0.0001

Source: Vandemark et al., 2014

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**Feed the Future Innovation Lab for Collaborative Research on Grain Legumes**

Slide from P. McClean
Seed Yield Gap
U.S. vs. Developing Regions

\[ R^2 = 0.38 \]
\[ b = 15.2 \]
\[ P < 0.01 \]

\[ R^2 = 0.16 \]
\[ b = 12.2 \]
\[ P = 0.02 \]

**Region**
- **Latin America and Caribbean**
  - Avg. Yield: 856 kg ha\(^{-1}\)
  - Potential Yield: 1800 kg ha\(^{-1}\)
  - Yield Gap: 944 kg ha\(^{-1}\)
  - Yield Gap: 52%

- **East and South Africa**
  - Avg. Yield: 675 kg ha\(^{-1}\)
  - Potential Yield: 2020 kg ha\(^{-1}\)
  - Yield Gap: 1345 kg ha\(^{-1}\)
  - Yield Gap: 67%

- **West and Central Africa**
  - Avg. Yield: 840 kg ha\(^{-1}\)
  - Potential Yield: 2125 kg ha\(^{-1}\)
  - Yield Gap: 1285 kg ha\(^{-1}\)
  - Yield Gap: 60%

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

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**Milpa Cropping System**

*Beans Go To Local Market For Cash*

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

**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 pumpkin, peas, and faba beans also included within the Milpa system in some cases.
**Milpa Cropping System**
*Prevalent Throughout the Highlands*

**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

**Case: Guatemala Bean Production Regions**

- **Lowlands**
  - Monoculture
- **Highlands**
  - Milpa

**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”
- 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
    - F3-F4 generation in 3 years?
    - Agronomic evaluation under different production systems.
    - Release of selected germplasm
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).
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

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

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.