Project S01.A4

Presentation for the Legume Innovation Lab Global Meeting

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Legume Innovation Lab Project S01.A4

Development and implementation of robust molecular markers and genetic improvement of common and tepary beans to increase grain legume production in Central America and Haiti.

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

Lead U.S. Country Principal Investigators, Institutions

- James Beaver and Consuelo Estévez de Jensen - University of Puerto Rico, Mayagüez, PR, USA
- Timothy Porch - USDA/ARS/TARS, Mayaguez, PR, USA
- Juan Osorno and Phil McClean – North Dakota State University (NDSU), Fargo, ND, USA

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Lead Host Country Principal Investigators, Institutions and Countries

- Juan Carlos Rosas - Escuela Agrícola Panamericana (Zamorano), Honduras
- Julio Cesar Villatoro - Instituto de Ciencia y Tecnología Agrícola (ICTA), Guatemala
- Emmanuel Prophete - National Seed Service, Ministry of Agriculture, Haiti

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Legume Innovation Lab Project S01.A4

Objective 1: Genetic improvement of common and tepary beans for Central America and Haiti.

Anticipated Achievements and Outputs

- Release and dissemination in the lowlands of Central America and the Caribbean of black, small red, white and pinto bean cultivars with multiple disease (BGYMV, BCMNV, rust, anthracnose, ALS) resistance and greater tolerance to low soil fertility.

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Bean Research Network

Bean lines trials distributed to research institutions of the Central American and Caribbean Bean Research Network

Trial name	Small red	Small black	Countries
VIDAC	66 + 2 checks	57 + 2 checks	ES, HO, NI, CR, PR, PA
ECAR	14 + 2 checks	14 + 2 checks	ES, HO, NI, CR, GU, HA
ERSAT	15 + 1 check	15 + 1 check	ES, HO, NI, CR, GU, PA
ERMAN	14 + 4 checks		ES, HO, NI, CR, GU
ERMUS	14 + 2 checks		ES, HO, NI, CR, GU

Bean research network

Planning meeting and field day for the release of improved small red and black bean cultivars with NARs and NGOs technical personnel and farmers from Honduras, El Salvador and Nicaragua (Zamorano, April 2014).

Goal: Increased on-farm testing of promising bean lines

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S01.A4 breeding activities

Recurrent selection for enhanced BNF and root rot resistance.	**Zamorano, UPR, TARS**
Recurrent selection for web blight resistance.	**Zamorano, UPR**
Breeding small red and black bean for angular leaf spot resistance [*Pgh-1* (Andean) + *Pgh-2* (MA)].	**Zamorano, TARS**
Breeding black beans for anthracnose resistance (*Co-4*^{2}).	**ICTA**
Breeding white, black and small red beans for rust resistance.	**Zamorano, UPR**

Adaptation to low N soils- BNF

- Selected small red and black breeding lines from second cycle of recurrent selection with greater nodulation, plant growth, seed yield, and resistance to BCMV and BGYMV, distributed to NARs for field evaluation in diverse conditions.
- Greater nodulation in the field (0.08 % N), soil: sand benches (0.06% N) and plastic pouches (nodulation speed) with *Rhizobium tropici* (CIAT 899) and *R. etli* (CIAT 632). Poor response to *R. leguminosarum* (UPR 2010).
- Dissemination of *Rhizobium* inoculant in Honduras, Nicaragua, Guatemala and Haiti.

Adaptation to low fertility soils in PR

- Porch et al. 2014. Registration of a small-red dry bean germplasm, TARS-LFR1, with multiple disease resistance and superior performance in low nitrogen soils. J. Plant Reg. 8:177-182.
- Porch et al. 2012. Registration of TARS-MST1 and SB-DT1 multiple-stress-tolerant black bean germplasm. J. Plant Reg. 6: 1: 75-80.
- Collaboration with Jim Kelly and Consuelo Estevez in the evaluation of 'Zorro x Puebla 152' RILs in a low N soil at Isabela, Puerto Rico.

Nodulation of TARS-LFR-1 (10IS-2423) with *Rhizobium tropici* strain CIAT 899, 30 days after inoculation

- Isabela, Puerto Rico

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Angular leaf spot (ALS)

- Characterization of pathogenic variability of *Phaeoisariopsis griseola* and use of inoculant from virulent races (i.e. 63-59 and 63-63) for selection.
- Use of molecular markers SH-13 (*Phg-1*), SN02 (*Phg-2*) and E-ACA/M-CTT$_{330}$ (G10474 dominant gene) for MAS of breeding lines and cultivars.
- Development and validation of ALS (+BCMV and BGYMV) resistant, high yielding and commercially acceptable small red bean (ALS 0532-6) and black bean (ALS 0546-60).

Reactions[1] of bean lines inoculated at the USDA-ARS-BARC with different races of rust.

	Rust race							
Line	41	44	47	49	53	67	73	108
Aurora (*Ur-3*)	R	S	S	S	R	S	S	R
Early Galatin (*Ur-4*)	S	R	S	R	S	S	R	R
Mexico 309 (*Ur-5*)	R	R	R	S	R	S	S	S
GG Wax (*Ur-6)*	S	R	R	S	S	S	R	S
GN 1140 (*Ur-7*)	S	R	R	R	S	R	S	R
PI 181996 (*Ur-11*)	R	R	R	R	R	R	R	S
PR0806-80	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**
PR0806-81	**R**	**R**	**R**	**R**	**R**	**R**	**R**	**R**

[1] R = resistant, S = susceptible

Web blight

- Development and release of ICTAZAM from the first cycle of recurrent selection.
- Beaver et al. 2012. Registration of PR0401-259 and PR0650-31 dry bean germplasm lines. J. Plant Reg. 6:81-84.
- Need to broaden the genetic base of resistance.

Anticipated Achievements and Outputs

- Development and testing in the lowlands of Central America and the Caribbean black, white and Andean bean breeding lines with resistance to bruchids, BGYMV, BCMV and BCMNV.

Laboratory bruchid evaluations

Susceptible

Resistant

Screening for bruchid resistance

Line	Days after infestation[1]		
	38	45	63
PR 1336-74	1.0 (0/10)	1.0 (0/10)	1.0 (0/10)
PR 1336-75	1.0 (0/10)	1.0 (0/10)	1.0 (0/10)
AO 1012-29-3-3A	1.0 (0/10)	1.0 (0/10)	2.0 (1/10)
RAZ 50 (*Arc-1*)	5.0 (7.0/10)	4.5 (7.0/10)	
RAZ 75 (*Arc-1*)	4.5 (5.0/10)	4.5 (7.0/10)	
Verano		3.6 (4.6/10)	
Badillo		4.2 (5.6/10)	

[1] Evaluated on a 1-5 scale where 1=absence of symptoms and 5=severe symptoms (Number of damaged seed /Total number of seed).

Natural infestation trial

Anticipated Achievements and Outputs

- Development and testing in the Caribbean and Africa of yellow and red mottled bean lines with resistance to BGYMV, BCMNV and BCMV

Andean bean research

- Release of red mottled lines PR0737-1 and PR0633-10 that combine BGYMV, BCMV and BCMNV resistance. Prophete et al. 2014. J. Plant Reg. 8:49-52.
- Development of yellow bean lines that combine resistance to BGYMV and BCMV.
- Selection of 'Rojo' backcross lines from Oregon State Univ. with bruchid resistance and *I* & *bc1*^{2} genes for resistance to BCMV and BCMNV

Anticipated Achievements and Outputs

- Development and testing in the Caribbean and Africa of tepary bean lines with virus resistance and improved agronomic traits.

Tepary bean research

- Release of Tep-22 that combines resistance to common bacterial blight, rust and seed weevil and tolerance to heat and drought (Porch et al. 2013. J. Plant Reg. 7:358-364).
- Development of breeding populations for improved agronomic traits and seed size.
- Possible source of BCMV resistance identified in tepary bean germplasm. This is a useful trait for tepary bean growers in the U.S.

Tim Porch and tepary bean lines in Juana Diaz, Puerto Rico

Characterization of a subset of the CIAT tepary bean collection showing a resistance response to NL3 (BCMNV) inoculation.

Tepary accession	Seed Color	Origen	NL3 inoculation	
			Response	Repeatability
G40041	White	South Africa	Veinal necrosis	consistent
G40042	White	Nebraska, USA	Veinal necrosis	consistent
G00044	Brown	South Africa	Veinal necrosis	consistent
G40177E	Brown	Arizona, USA	Pinpoint necrotic lesions	consistent
G40177E1	Brown	Arizona, USA	Veinal necrosis	consistent

Source: Vargas et al. 2014. Evaluation of the tepary bean (*Phaseous acutifolius*) CIAT germplasm collection for response to common bacterial blight and bean common mosaic necrosis virus. Ann. Rep. Bean Improv. Coop. 57:181-182.

Tepary bean research

- Seed increase of tepary bean collection for testing of resistance to drought, heat and BGYMV in Honduras.

Seed increase of Lima bean landrace ‘Beseba’ in Damien, Haiti

‘Beseba’ Lima bean

- ‘Beseba’ is a Haitian Lima bean landrace that was in Caribbean landrace collection sent to CIAT.
- Dr. Rao reported at the 2014 PCCMCA meeting in Nicaragua that ‘Beseba’ (G25529) produced the greatest seed yield in high temperature trial conducted in Colombia.
- Emmalea Ernest reported at the most recent BIC meeting that G 27529 and G 27525 had among the greatest amount of pollen shed in a high temperature trial conducted in Delaware (BIC 57:41-42).

Intercropping ‘Sieva’ Lima bean with maize in Isabela, Puerto Rico

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Objective 2: Develop and implement robust molecular markers for disease resistance genes.

Anticipated Achievements and Outputs

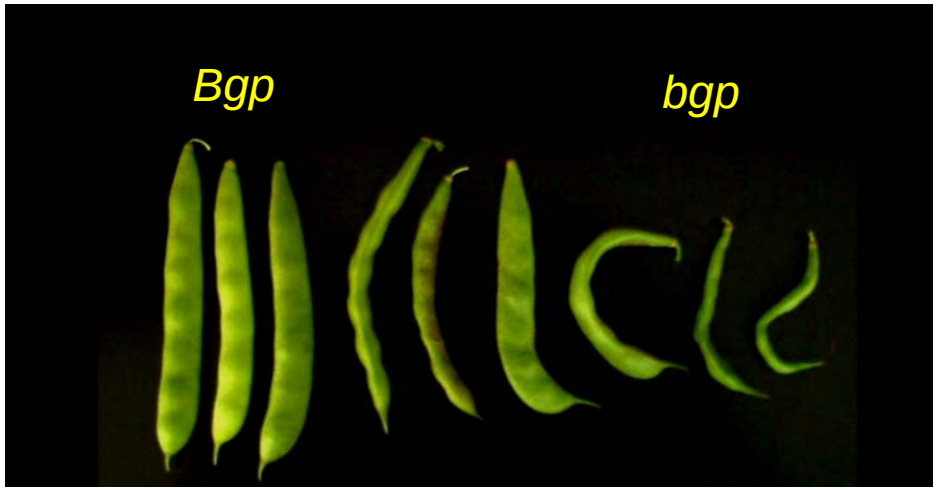
- Genome-wide association mapping will be used to fine map the genomic regions associated with disease resistance genes and other traits of economic importance.

Anticipated Achievements and Outputs

- Develop Indel markers for traits of economic importance (*Bgp* gene, ashy stem blight and powdery mildew resistance) that will facilitate the selection of bean lines with the desired combination of traits.

Indel Molecular Markers

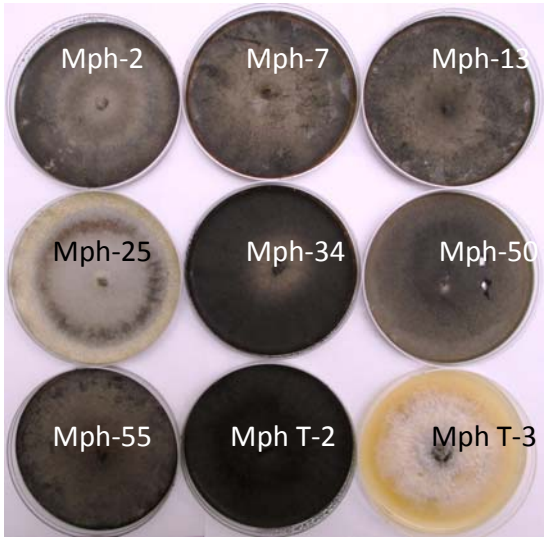
- Compatible with agarose gels and conventional PCR techniques – portability among labs
- Codominant – detect heterozygous plants
- Amenable to multiplexing with suites of markers



Resistance to pod deformation in the presence of BGYMV.

Acevedo-Román et al. 2004. J. Amer. Soc. Hort. Sci. 129:549-552

Powdery mildew on beans in the Dominican Republic



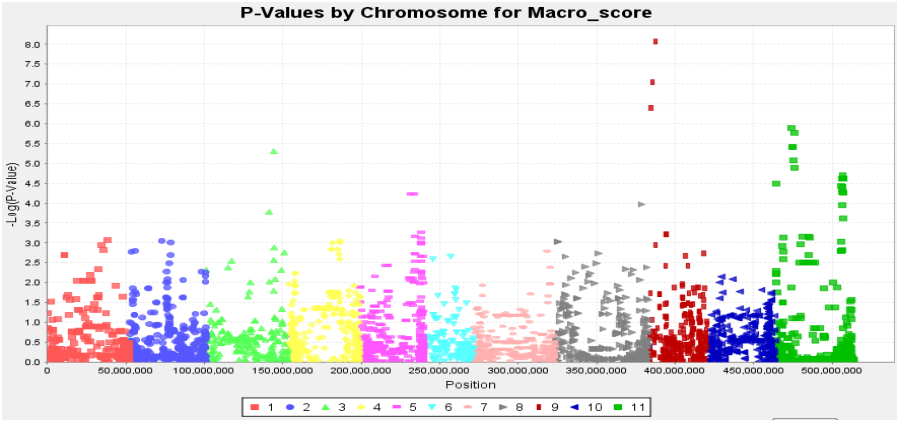
Macrophomina phaseolina collected in Puerto Rico for the evaluation of virulence and for genotypic diversity analysis.

Table 1. Andean Diversity Panel genotypes with resistant (1-3) responses to *Macrophomina phaseolina.*

Genotype	ADP #	Seed type	Source	Agron. score[1] (1-9)	Mat. score[1] (1-3)	Macro. score[1] (1-9)
ROZI KOKO	ADP-1	Red mottled	Tanzania	5.3	2.3	3.0
NABE 4	ADP-166	Red mottled	Uganda	5.0	2.0	3.3
Favinha	ADP-343	Red mottled	Brazil	5.0	2.0	3.3
49-2	ADP-440	Yellow	Haiti	5.0	2.3	3.3
Rojo	ADP-96	Red kidney	Tanzania	6.0	2.3	3.7
Badillo	ADP-128	Red kidney	Puerto Rico	5.0	2.0	3.7

[1]Agronomic score on 1-9 scale with 1 being desirable and 9 undesirable; Maturity score on 1-3 scale with 1 being early and 3 late; Macrophomina score on 1-9 scale with 1 resistant and 9 highly susceptible.

Source: Porch et al. 2014. Ann. Rep. Bean Improv. Coop. 57:189-190.



Association mapping analysis results of the Andean Diversity Panel to inoculation of *Macrophomina phaseolina* (ashy stem blight) in Isabela, Puerto Rico.

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Objective 3: Strengthen the capacity of bean programs in Central America and the Caribbean to conduct research and develop, release and disseminate improved bean cultivars.

Anticipated Achievements and Outputs

- Technical personnel in Central America and the Caribbean with greater capacity to produce reliable and repeatable results from field trials and to develop and release improved cultivars.

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Degree Training - Project S01.A4

Name	Gender	Country	Degree Discipline	Institution
M.J. Cunguan C. Lopez	F F	Ecuador	B.S. Agronomy	Zamorano
L.A. Avila R.J. Escobar S.D. Chicas	F M F	El Salvador	B.S. Agronomy	Zamorano
M.D. Goyzueta	M	Bolivia	B.S. Agronomy	Zamorano
E.D. Gutierrez M.G. Cruz	M F	Honduras	B.S. Agronomy	Zamorano

Degree Training - Project S01.A4

Name	Gender	Country	Degree Discipline	Institution
A. Vargas	F	Nicaragua	M.S. Plant Breeding	UPR
A. Miranda	F	Guatemala	M.S. Plant Breeding	UPR
B. Mateo	M	Dom. Rep.	M.S. Plant Breeding	UPR

Degree Training - Project S01.A4

Name	Country	Degree Discipline	Institution
TBD	TBD	Ph.D Plant Breeding	NDSU
TBD	TBD	Ph.D Plant Breeding	NDSU

Informal Training - Project S01.A4

- In-service training will be provided at NDSU for Legume Innovation Laboratory scientists to review recent advances in sequencing the bean genome and the utilization of SNP arrays to develop indel markers for traits of economic importance

Informal Training - Project S01.A4

- Workshops will be held at Zamorano to train technical personnel concerning bean research techniques with the goal of improving the quality of field research.
- Proposed workshop for technical personnel concerning the production, processing and storage of breeder and foundation seed stocks.

Goal: Increased production of breeder and foundation seed stocks.

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Continued collaboration with CRSP alumni institutions

- Bruchid resistance research with Paul Kusolwa at Sokoine Agricultural Univ. in Tanzania
- Evaluation of red mottled and black bean breeding lines by IDIAF in the Dominican Republic.
- Regional performance trials (SISTEVER) in Nicaragua, El Salvador and Costa Rica.
- Evaluation of Andean and pinto bean lines in Angola.

Continued collaboration with CRSP alumni institutions

- Collaboration extends the potential impact of Legume Innovation Lab research.
- Generates information that is valuable to the global bean research community.
- Suggestion: Permit the use of strengthening grant funds for informal training and travel of bean researchers in CRSP alumni institutions.

Collaborative disease screening of the Andean Diversity Panel in South Africa (March 22-29, 2014)

Posted on April 8, 2014 by ftfadmin

ARS collaborators in Potchefstroom at Halo blight field trial (left). Dr. Deidre Fourie with halo blight trial in the greenhouse in Potchefstroom (right).

USDA/ARS Feed the Future: http://arsftfbean.uprm.edu/bean/

Feed the Future Innovation Lab for Climate Resilient Beans, a USAID project led by Dr. Jonathan Lynch at Penn State University.

The project mission is to integrate phenomics, genomics, and accelerated breeding programs to produce more resilient, productive bean varieties for smallholder farmers.

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

Relationship between S01.A4 and other Feed the Future Projects

- Focus on biotic constraints vs. abiotic constraints (successful bean cultivars need resistance/tolerance to both types of constraints).
- Focus on Latin America/Caribbean vs. Africa (exchange of breeding lines mutually beneficial).
- Genomic research, development of molecular markers and breeding strategies are common links among projects.

Thank you for your attention