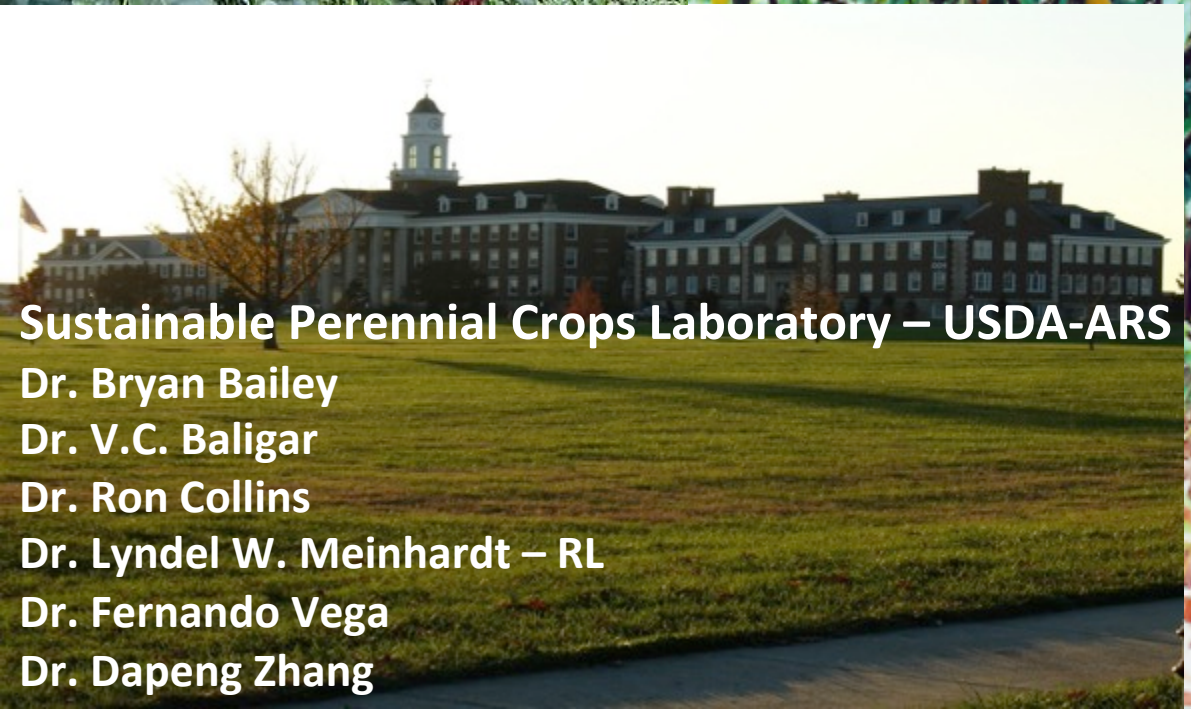


**Sustainable Perennial Crops Laboratory – USDA-ARS**


**Dr. Bryan Bailey**
**Dr. V.C. Baligar**
**Dr. Ron Collins**
**Dr. Lyndel W. Meinhardt – RL**
**Dr. Fernando Vega**
**Dr. Dapeng Zhang**

The mission of the Sustainable Perennial Crops Laboratory is to carry out research on tropical perennial crops of significance to national and global economies with the goals of:

improving and maintaining crop yields with reduced inputs

reducing the impact of crop disease

preserving and optimizing the use of crop genetic diversity

mitigating the negative environmental impacts resulting from crop production

Thus providing U.S. consumers and industries with safe and stable supplies of these commodities.

80 Billion $

10 -15 Billion $

Four National programs

NP301

NP303

NP304

Np305

Three main commodities

20-25 Billion $

Other US commodities used to make chocolate

653 million lbs milk product

3 billion lbs sugar

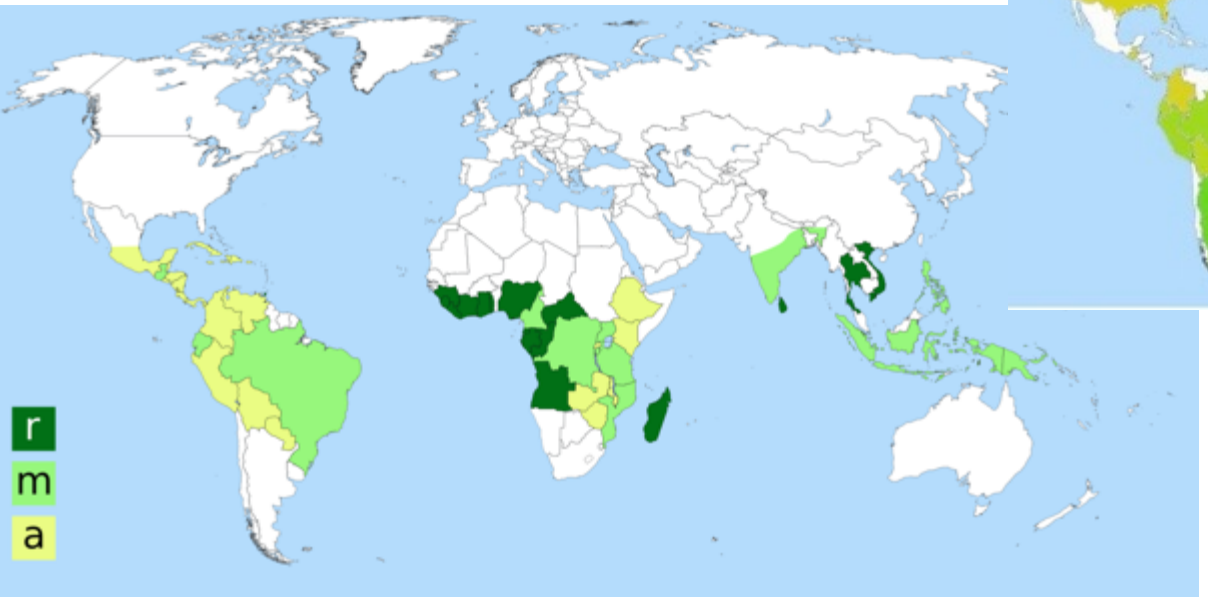
360 million lbs peanuts

43 million lbs almonds

1.7 billion lbs corn sweeter


Dr. Lyndel Meinhardt


Major Tea Producers
Minor Tea Producers


r
m
a

We are using elite clones in bonsai form.

Orthotropic rooted cutting

Plagiotropic rooted cutting

# Genetic diversity assessment of cacao and other tropical tree crop genetic resources

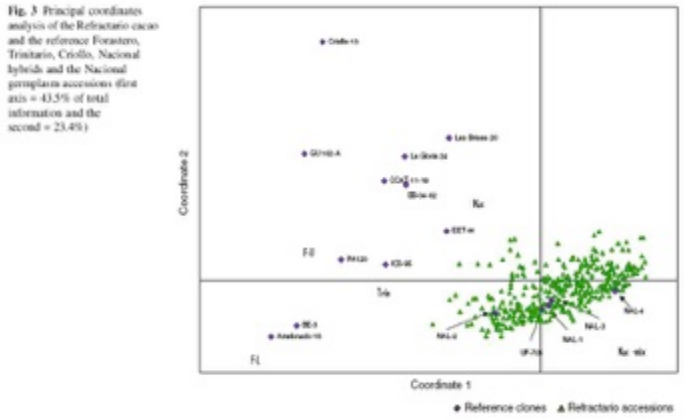
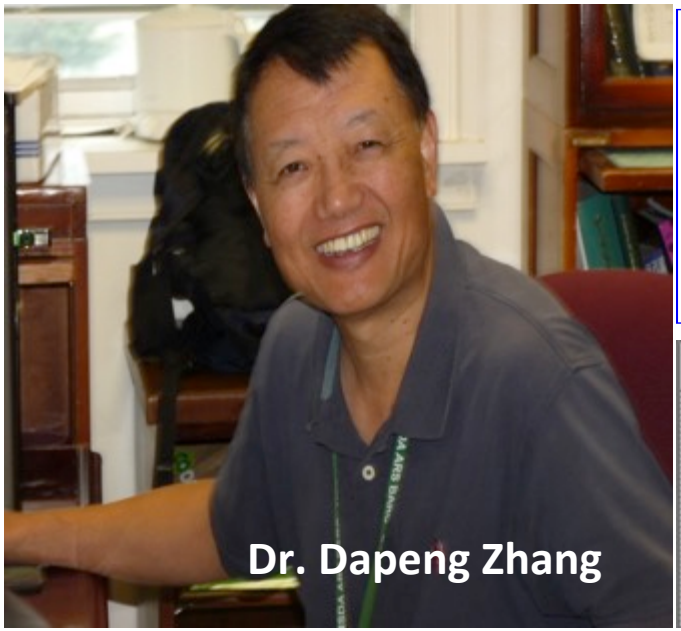
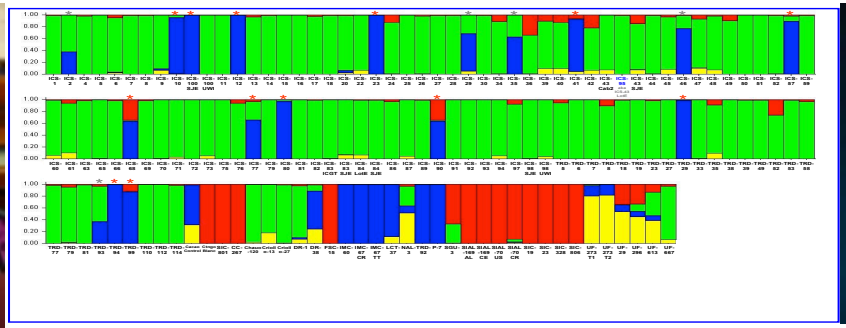
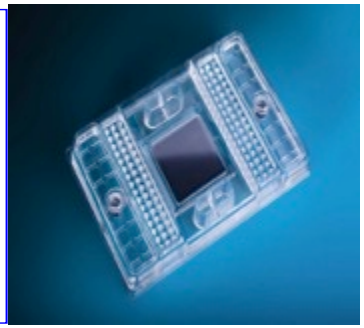
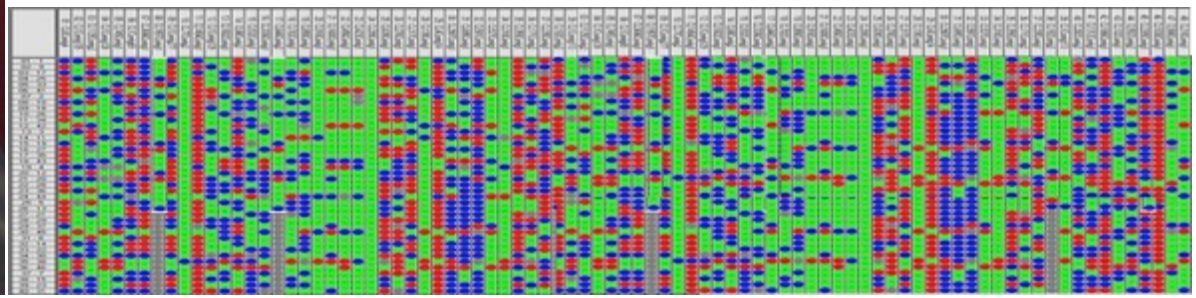



Fig. 3 Principal coordinates analysis of the Refractario cacao and the reference Forastero, Trinitario, Criollo, Nacional hybrids and the Nacional germplasm accessions (first axis = 43.5% of total information and the second = 23.4%)







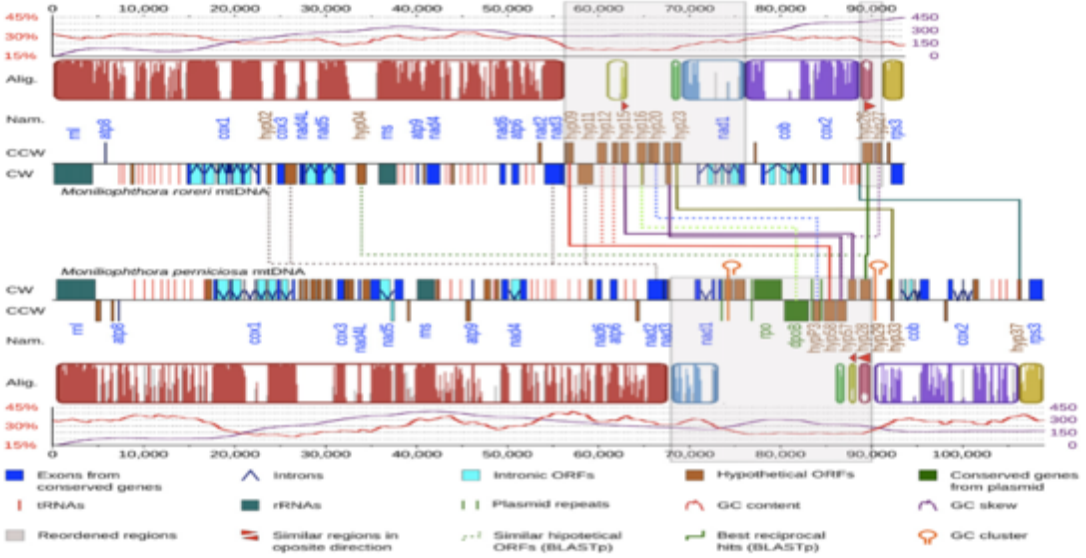
SPCL
Sustainable Perennial Crops Laboratory
USDA - BELTSVILLE AGRICULTURAL RESEARCH CENTER

# Background and Rationale

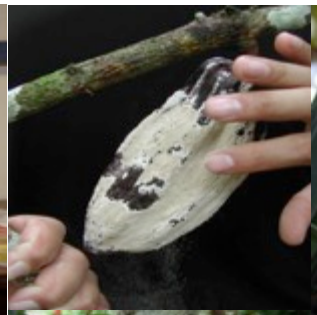
- A complete understanding of the genetic diversity of cacao within the center of origin is lacking
- There is a rapid genetic erosion in farmers' fields (monoculture and/or replacement with limited clonal material), which also results in the loss of traditional varieties
- There is a need for scientific information about the dynamics of diversity change in farmer's fields, especially in the center of origin and center of diversity of cacao.

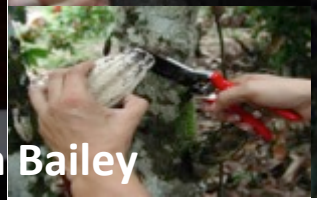
Dr. Dapeng Zhang Beltsville, Maryland

# Genomic Characterization and Management of Fungal Diseases of Cacao









**Frosty pod Rot**

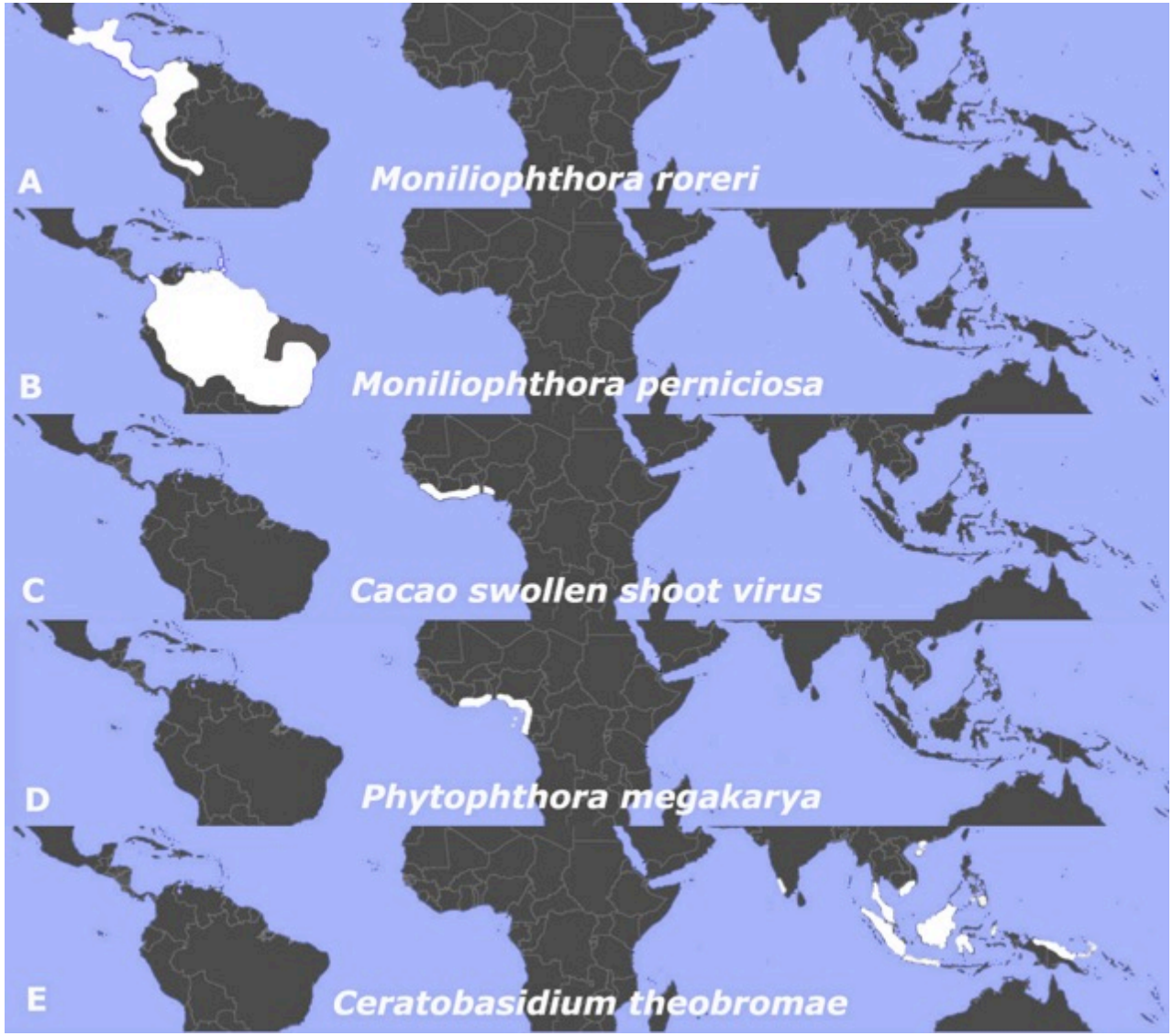
*Moniliophthora roreri*

**Vascular-streak dieback (VSD)**

*Oncobasidium theobroma*

**Black pod**

*Phytophthora palmivora, P. megakarya*




*Lasiodiplodia theobromae*-tip dieback and charcoal rot

1480 up-reg at 60 DPI (5X) - Pathogen growth and plant cell death

724 hypothetical proteins

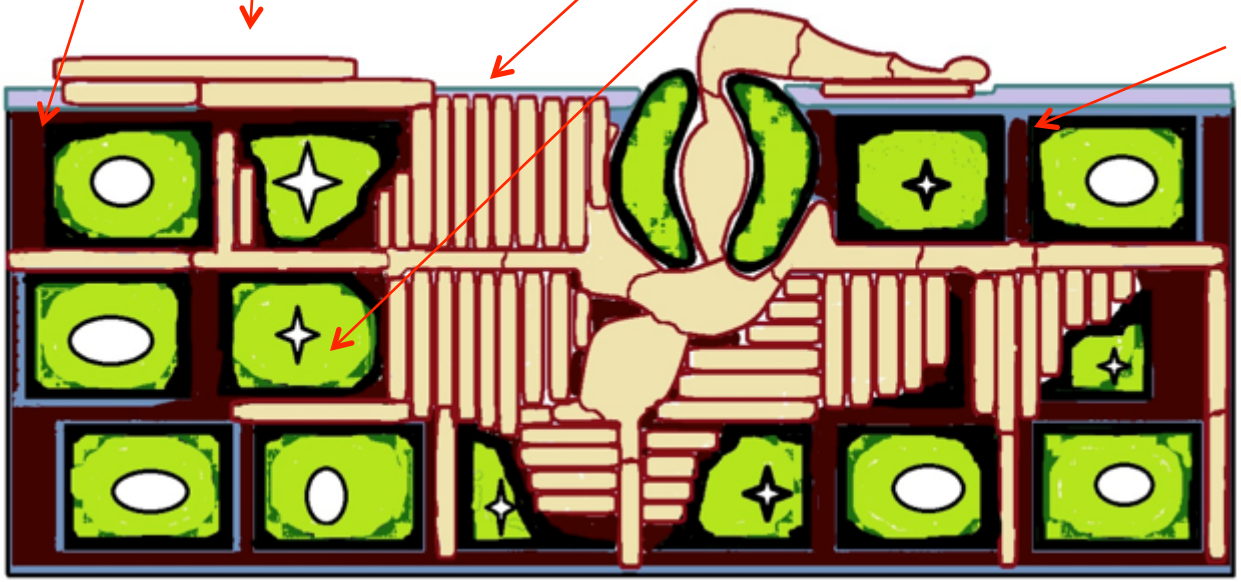
Lignin breakdown- Laccases (5) , aryl alcohol oxidases (5), glyoxal oxidase (2)

Reproduction & growth - Hydrophobins (14), Cytochrome P450 (39), actin (1)
Chitin synthase (2) chitin deacetylase (9),

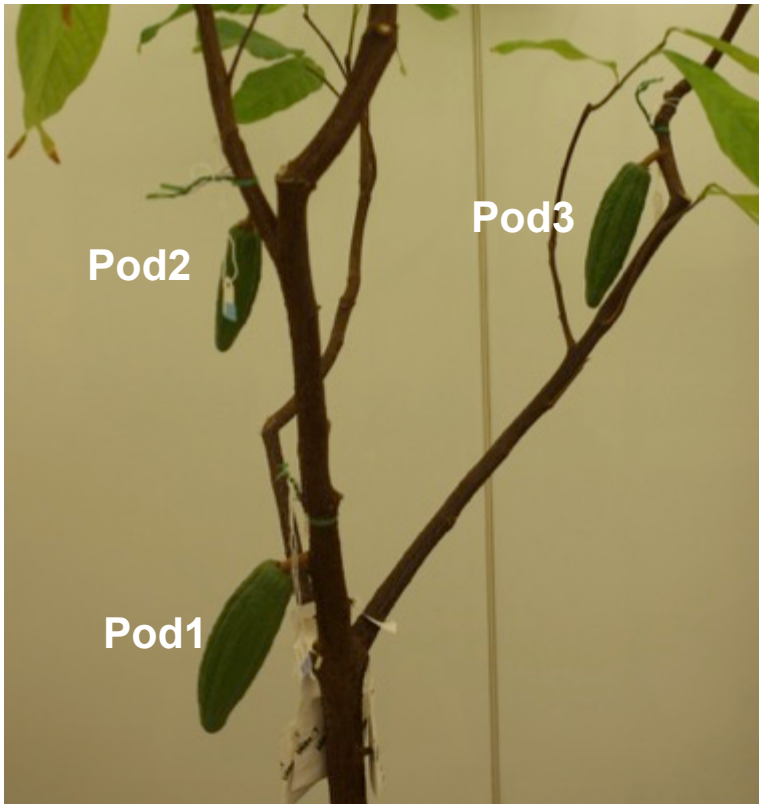
Lipid breakdown - lipases (7), cutinase (1)

Cell death - Necrosis inducing protein (1), cerato-platanins (3)

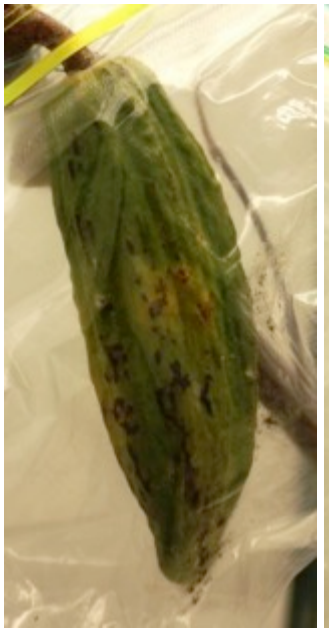
Expansins (3), heat shock (5),
PR-1 (3), )



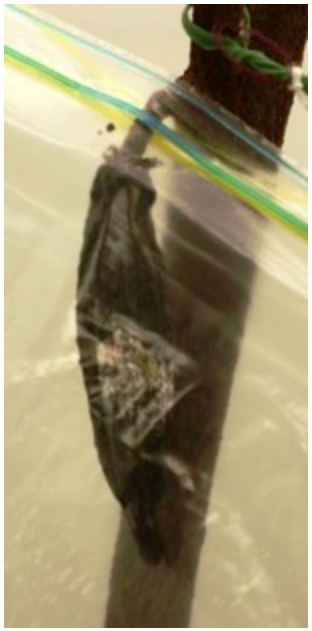
46 glycoside hydrolases




Pod1



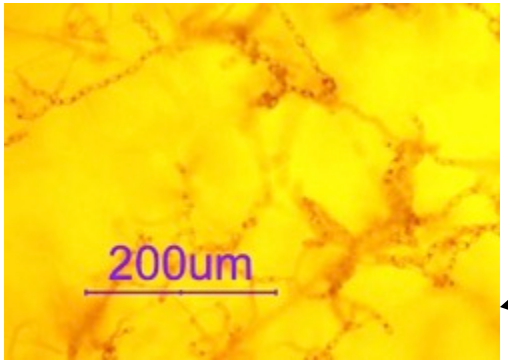
Pod2



Pod3

On 2/5/16, Day 49

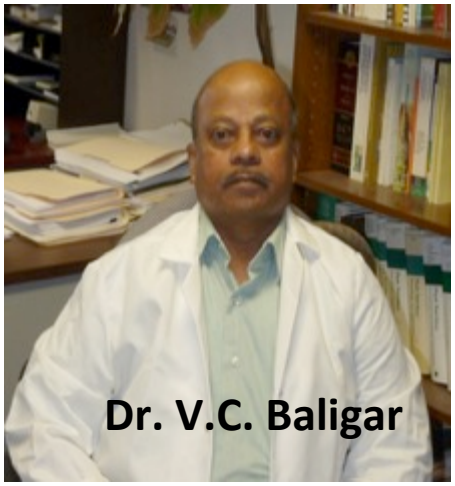
Date of infection 12/18/2015




V8 agar plate 15 day old culture


Pod1


# Sustainable Production Systems for Cacao




# RESEARCH AREAS OF INTEREST

- **CACAO GENOTYPE EVALUATION FOR ABIOTIC STRESS TOLERANCE**

  -Drought
  -Acid Soil
  -Light Quality
  -Cd toxicity

- **IMPROVED MANAGEMENT SYSTEMS**

  -Cabruca, Agroforestry, open canopy
  -Soil Quality
  -Nutrient management
  -Productivity/ quality bean

- **COVER CROPS**

  -Compatibility
  -Tolerance to Abiotic Stresses
  -Soil Quality
  -Cacao Productivity/ quality bean

# Development of Biological Control Technologies and Strategies for Arthropod Pests of Perennial Tropical Crops Important to the U.S., Particularly Coffee


# *Breeding for Disease Resistance in Cacao*

**O. A. Gutierrez, D. Livingstone III, and Alina S. Campbell**

USDA-ARS, SHRS, Miami, FL

**Guiliana Mustiga,**

**R. J. Schnell, and J. C. Motamayor**

MARS, Inc.

**Wilbert Phillips-Mora**

CATIE

**Pound 7**
**Tolerance to BP**
**high susceptibility to FP**

**UF 273**
**Tolerance to FP and**
**moderate susceptibility to BP**

## FP-BP Mapping Population:

**‘Pound 7’ (A)** X **‘UF 273’ (B)**

↓

***CATIE***

**$F_1$ plants ( 181 plants)**

# Illumina Infinium 6k SNP Chip

- 6,000 single bead type SNPs submitted to Illumina
- 1,152 cacao DNA extracts submitted for genotyping
  - Diversity Panel Members
  - Three Mapping Populations:

    FP-BP Pound7 x UF273 (249, CATIE)
    BP-VSD KA2-101 x K82 (344, PNG)
    WB TSH1188 x CCN51 (498, MCCS)

# Materials and Methods

- **Results**
  - **181 'Type 1' progeny**
- **FPR was evaluated using a 1 to 5 scale scoring for internal and external infection (Phillips-Mora 1996). BPR was evaluated using the method of Crouzillat *et al.* (2000), scoring 10 dpi.**
- **Trees were inoculated 6-10 times from (2000-2004).**

# *Phenotypic Evaluation*

- **LS means for FP and BP reactions per tree were calculated using a mixed linear model (Proc Mixed of SAS V9)**
- **Linkage maps were constructed using 181 $F_1$ plants and 5,470 SNPs.**
- **JoinMap 4.1 Two-way pseudo-test cross analysis**
- **MapQTL 6.0 Interval Mapping using DH population. LOD values were estimated using a permutation test (2000)**

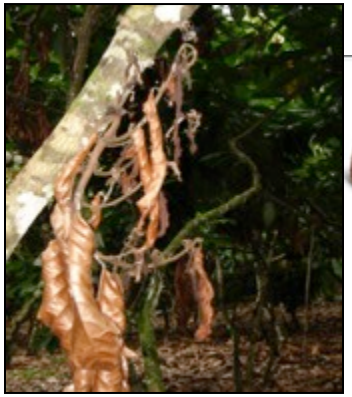
# Quantitative trait loci (QTLs) for FP and BP found and descriptive information for use in selecting progeny.

| QTL name | LG | Significance Threshold | LOD peak | %Variance Explained | First flanking marker | Second flanking marker | mu_A | mu_B | Additive |
|---|---|---|---|---|---|---|---|---|---|
| FP-ES | 9 | 3.2 | 4.46 | 11.1 | P2Tcm009s41830730 | P2Tcm009s41752745 | 2.30471 | 1.97921 | 0.162751 |
| FP-IS | 2 | 3.3 | 5.01 | 12.4 | P2Tcm002s000773168 | P2Tcm002s01585136 | 3.21105 | 2.63597 | 0.287537 |
| FP-IS | 9 | 3.3 | 4.05 | 10.2 | P2Tcm009s41973167 | P2Tcm009s41905844 | 3.19866 | 2.67654 | 0.261061 |
| BP | 10 | 3.8 | 13.42 | 29.5 | P1Tcm010s22418501 | P1Tcm010s23376208 | 0.318179 | 1.07350 | -0.377661 |

* Note work in progress-Screening of 340 an $F_2$ population of the same cross with 10,000 SNPs


RUSSIA
CANADA
UNITED STATES
CHINA
INDIA
BRAZIL
AUSTRALIA
ALGERIA
LIBYA
EGYPT
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
SOUTH PACIFIC OCEAN
SOUTHERN OCEAN


Caribbean Sea
North Atlantic Ocean
VENEZUELA
COLOMBIA
AMAZON BASIN
PERU
BRAZIL
BRAZILIAN HIGHLANDS
South Pacific Ocean
ANDES
BOLIVIA
PARAGUAY



Collaborations

CRC Trinidad/Tobago

ICT Peru

CATIE Costa Rica

CEPLAC Brazil

EMBR

CIRAD

ICCRI

KEW

ECOSU

CRIG

Universities

PSU

UF

NMSU

Morgan State

# **Corpoica** and others in Colombia

TARS – Mayaguez PR

SHRS – Miami Fl

TPGRDRU – Hilo Hawaii

Stakeholders

WCF FCIA

Chocolate companies (Hershey, Mondelez, Ferrero, Mars)