

Long term Research and Technology Transfer to Increase Cacao Productivity at Mars, Incorporated



Genomics based breeding, and enhanced productivity



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MARS
chocolate

The Problem:

Low productivity continues to be an issue due to:

Ageing trees, pest and disease vulnerability, farmers' lack of access to inputs

Declining soil fertility and lack of access to and knowledge about appropriate fertilizers practices

Lack of knowledge and training access on good agricultural practices (GAP)

Lack of support for long term research and technology transfer

MARS Response:

MARS Response to these difficulties have been:

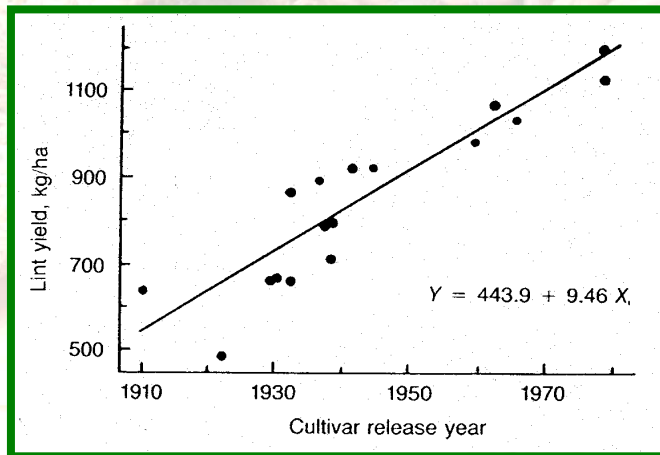
- Long term research
- Technology transfer
- Enhancing impact assessment
- Enhancing the productivity aspects of certification
- Public-private partnerships such as CocoaAction

Long term Research: Genetics a key area of research

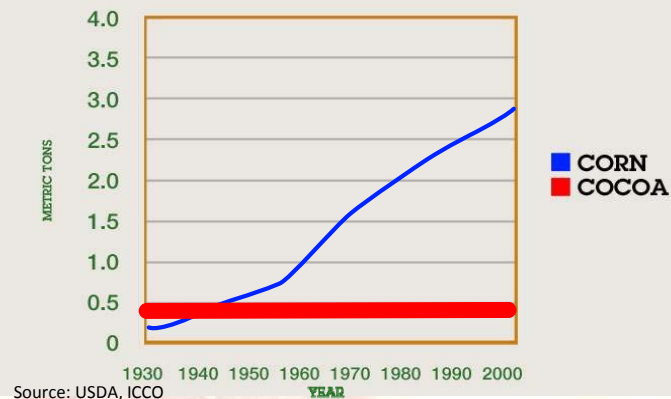
Breeding has the potential to provide a step change on productivity:



Cotton



Corn and Cocoa Yields Over Time



Genes determine traits combination



Photo: NATIONAL GEOGRAPHIC
MAGAZINE

<http://www.cacaogenomedb.org>

Data & Tools

Tools	Genome Sequence	
Batch BLAST		
BLAST (private)		
BLAST		
GBrowse (private)		
GBrowse		
CMap (private)		
CMap		
WebFPC		
CAP3 Assembly	Server	
SSR Server		

CMap

ViewEditTrack

CMap Home | Maps | Map Search | Feature Search | Matrix | Map Sets | Feature Search

Ref. Species: Cacao (Theobroma cacao)

Ref. Set: Select

The CMap Catalog

Quick Start

To view a map

1. Select

2. Select

3. Select

4. Select

5. Click on "Draw Selected Maps"

6. After Drawing the maps, you may also select one or two comparative maps

Please note: Javascript is required to use CMap.

[CMap Home](#) | [Maps](#) | [Map Search](#) | [Feature Search](#) | [Matrix](#) | [Map Sets](#) | [Feature Search](#)

Feature Search

Feature Name: mTcCIR106

Aliases: L1D0_mTcCIR106

Accession ID: 298

Feature Type: Marker

Species: Cacao

Map: Map Set: Consensus Disease Resistance QTLs

Map Name: consensus_disease_res_LG1

Start: 11.70 cM

Stop: 11.70 cM

Cross references: [GBrowse](#)

Feature	Accession	Map	Map Type	Aliases
mTcCIR106	753209	Cacao-Cacao physical map-Pseudo_chr1	Sequence	None
mTcCIR106	753209	Cacao-Cacao physical map-Pseudo_chr1	Sequence	None
mTcCIR106	Composite-1-1	Cacao-Composite (2008)-LG1	Genetic	None
mTcCIR106	Composite-1-1	Cacao-Composite (2008)-LG1	Genetic	None
mTcCIR106	F1_catie-1	Cacao-F1 CATIE (2007)-LG1	Genetic	None
mTcCIR106	F1_catie-1	Cacao-F1 CATIE (2007)-LG1	Genetic	None
mTcCIR106	768510	Cacao-Hort Trait QTLs-HortTrait_LG1	Genetic	L1D0_mTcCIR106

The screenshot displays the CMAP (Comparative Map) interface, which is used for genomic analysis and comparison across different traits and maps.

Top Section: Comparative Maps

- Comparative Disease Resistance QTLs:** Shows a consensus map with markers like *mTcCIR106* highlighted.
- Reference Cacao Physical map:** Shows contigs and gaps, with markers like *mTcCIR106* and *mTcCIR118* mapped.
- Comparative Cacao Hort Trait QTLs:** Shows markers like *mTcCIR106* and *mTcCIR118* mapped to specific traits.

Bottom Section: Detailed View of mTcCIR106

- Browser:** Shows the genomic context of the marker, including the super_1:2464727..2465317 region.
- Search:** Provides a search bar and filters for the marker.
- Overview:** Shows a genomic map with markers and a detailed view of the marker's location.
- Details:** Provides a detailed view of the marker, including its sequence, gene models, and transcript evidence.

View Edit Track

CMap Home | Maps | Map Search | Features

Ref. Species: *Cacao* (*Theobroma cacao*)

Ref. Set: --Select--

Genetic: *Cacao* - Pugh (2006)

Genetic: *Cacao* - F2 Brazil

Genetic: *Cacao* - F1 CATIE

Genetic: *Cacao* - F2 RGH

Genetic: *Cacao* - Compos

Genetic: *Cacao* - F2 RH

Genetic: *Cacao* - Disease

Genetic: *Cacao* - Hot Trait

Genetic: *Cacao* - Schell G

Sequence: *Cacao* - Cacao

those features that have corresponding maps but may be on comparative maps. Click on "Draw Selected Maps".

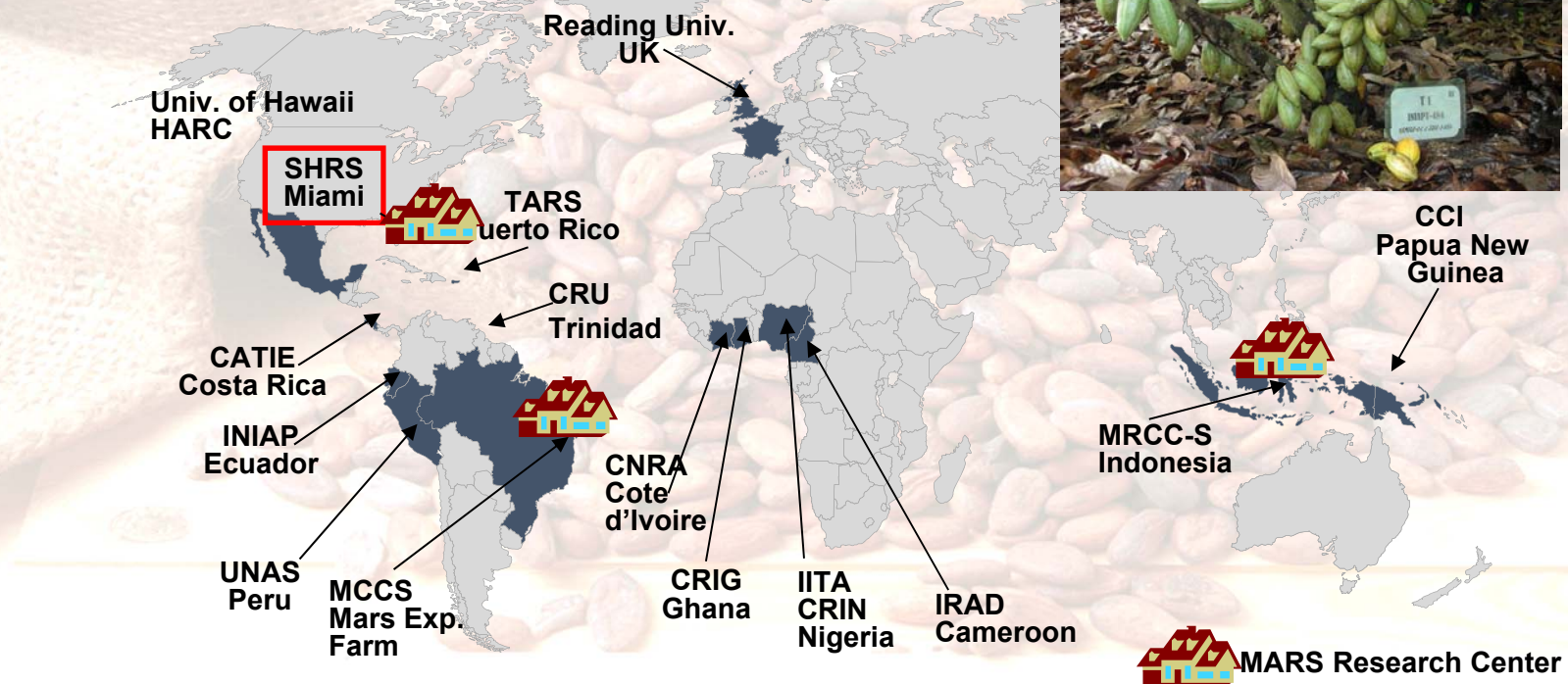
6. After Drawing the maps, you may select one or two comparative maps.

Please note: Javascript is required to use CMap.

Feature "mTcCIR106"											
Feature Name: mTcCIR106											
Aliases: L1D0_mTcCIR106											
Accession ID: Z98		[View Alias Details]									
Feature Type: Marker											
Species: Cacao											
Map: Map Set: Consensus Disease Resistance QTLs											
Map Name: consensus_disease_res_LG1											
Start: 11.70 cM											
Stop: 11.70 cM											
Cross references: GBrowse I											
Correspondences											
Feature	Accession	Map	Map Type	Aliases	Evidence Type						
mTcCIR106	753209	Cacao-Cacapo physical map-Pseudo_chr1	Sequence	None	Automated name-based	[Correspondence C					
mTcCIR106	753209	Cacao-Cacapo physical map-Pseudo_chr1	Sequence	None	Automated name-based	[Correspondence C					
mTcCIR106	composite-1_1	Cacao-Composite (2008)-LG1	Genetic	None	Automated name-based	[Correspondence C					
mTcCIR106	composite-1_1	Cacao-Composite (2008)-LG1	Genetic	None	Automated name-based	[Correspondence C					
mTcCIR106	F1_catie-1_2	Cacao-F1 CATIE (2007)-LG1	Genetic	None	Automated name-based	[Correspondence C					
mTcCIR106	F1_catie-1_2	Cacao-F1 CATIE (2007)-LG1	Genetic	None	Automated name-based	[Correspondence C					
mTcCIR106	768610	Cacao-Hort Trait QTLs-Hort Trait LG1	Genetic	L1D0_mTcCIR106	Automated name-based	[Correspondence C					

[illegible]

- Thousands of genotypes under evaluation
- Dozens of clones selected for various combinations of high yield, disease resistance and quality traits

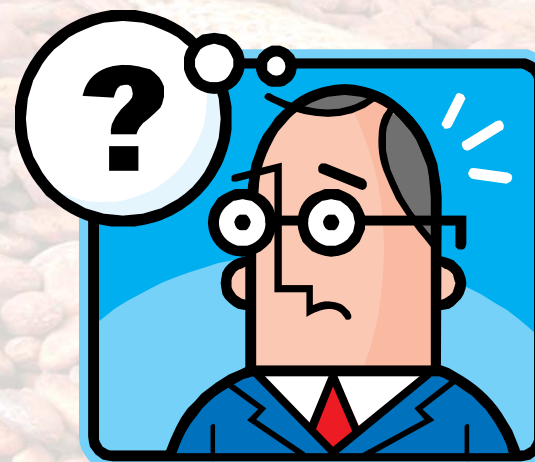


Long Term Cacao Research is Needed:

Pruning parameters in grape ([Jackson 2008](#))

Character assessed	Optimal Value
Canopy width	300-400mm
Shoot characters	10-15 nodes
Lateral development	Less than 5-10 lateral nodes total per shoot
Ratio of leaf area to fruit mass	~10cm ² /g (range 6-15 cm ² /g)
Ratio of yield to canopy surface area	1-1.5 kg fruit/m ² canopy surface
Ratio of yield to total cane mass	6-10
Internode length	60-80 mm
Ratio of total cane mass to canopy length	0.3-0.6 kg/m
.....	

Pruning in Cacao



Why Long Term Research Support is Needed:

- Cacao has a long biological cycle; projects with funding under five years generally have no time to achieve their goals
- The original genetic diversity in the center of origin of the species is disappearing due to deforestation and the international germplasm collections lack of funding as a consequence, trees representing unrecoverable genetic diversity are dying
- Research funding in cacao producing countries is very limited
- Research institutes outside cacao producing countries (i.e., CIRAD, CABI, USDA, etc.) have no longer or have decreased cacao research programs
- Research is implemented on small plots and results get rarely scaled out

The CDC/CVC Concept:

Research



Transfer



**Development /
Identification of High
Yielding Clones**

**Planting Material
Propagation**

Development of a critical
mass of budwood for
its distribution to farmers

Centralized budwood
gardens,
Somatic Embryogenesis

**Cocoa Development
Centers (CDCs):**

Demonstration of farm
rehabilitation and Good
Agricultural Practices and
coaching

**Cocoa Village Center
(CVCs):**

Sell inputs
and services
(includes
decentralized clonal
gardens/nurseries),
run by a trained
individual from the
cocoa community:
The Cocoa Doctor



CDC/CVC in Indonesia



Cocoa Doctor at its own CVC

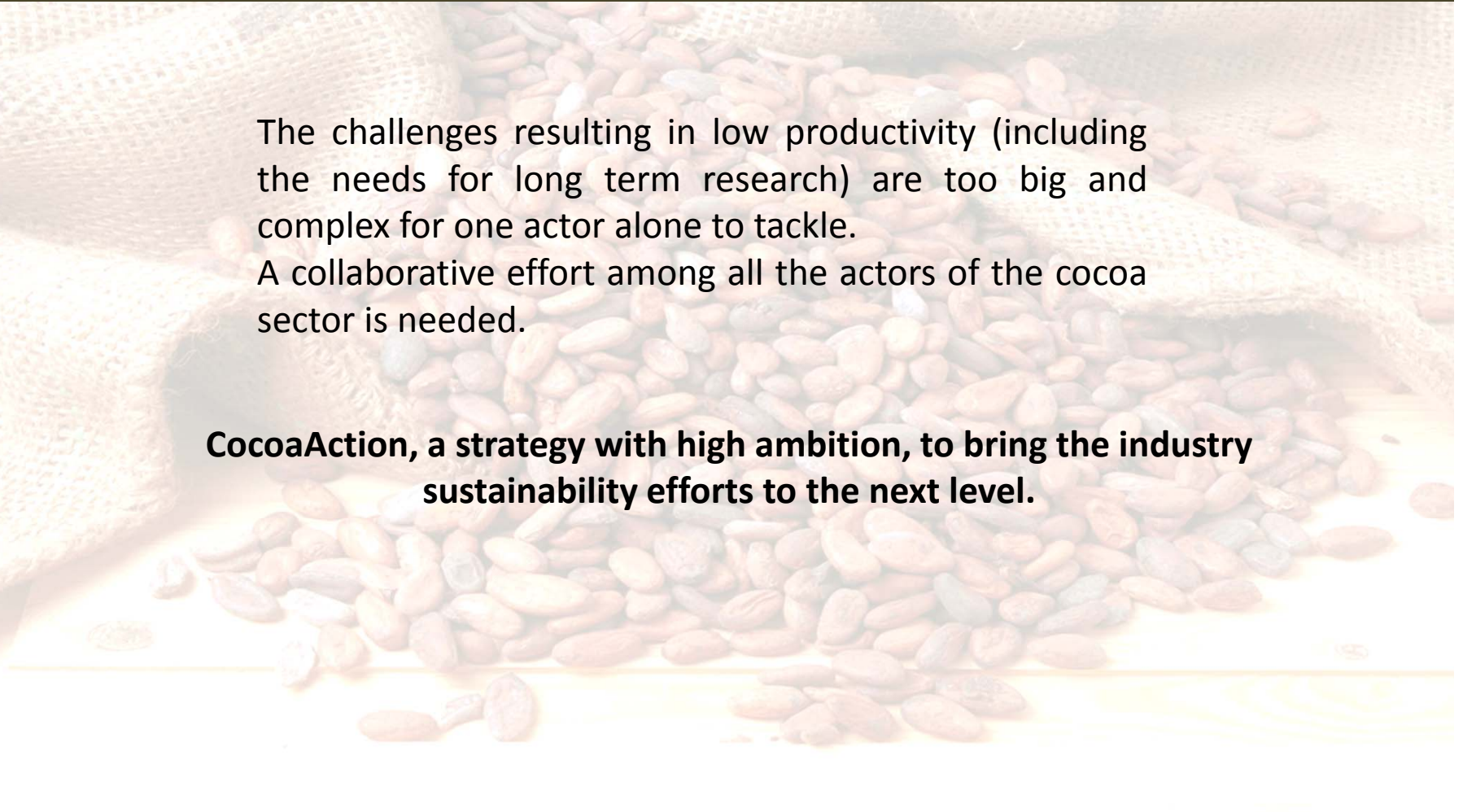


Farmer after rehabilitating through side grafting using improved planting material (yields tripled 3 years from grafting)

CocoaAction

The challenges resulting in low productivity (including the needs for long term research) are too big and complex for one actor alone to tackle.
A collaborative effort among all the actors of the cocoa sector is needed.

CocoaAction, a strategy with high ambition, to bring the industry sustainability efforts to the next level.





Thank You!