



United States Department Of Agriculture
Agricultural Research Service

Cacao Genetic Resources at the USDA-ARS TARS



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USDA-ARS, TARS



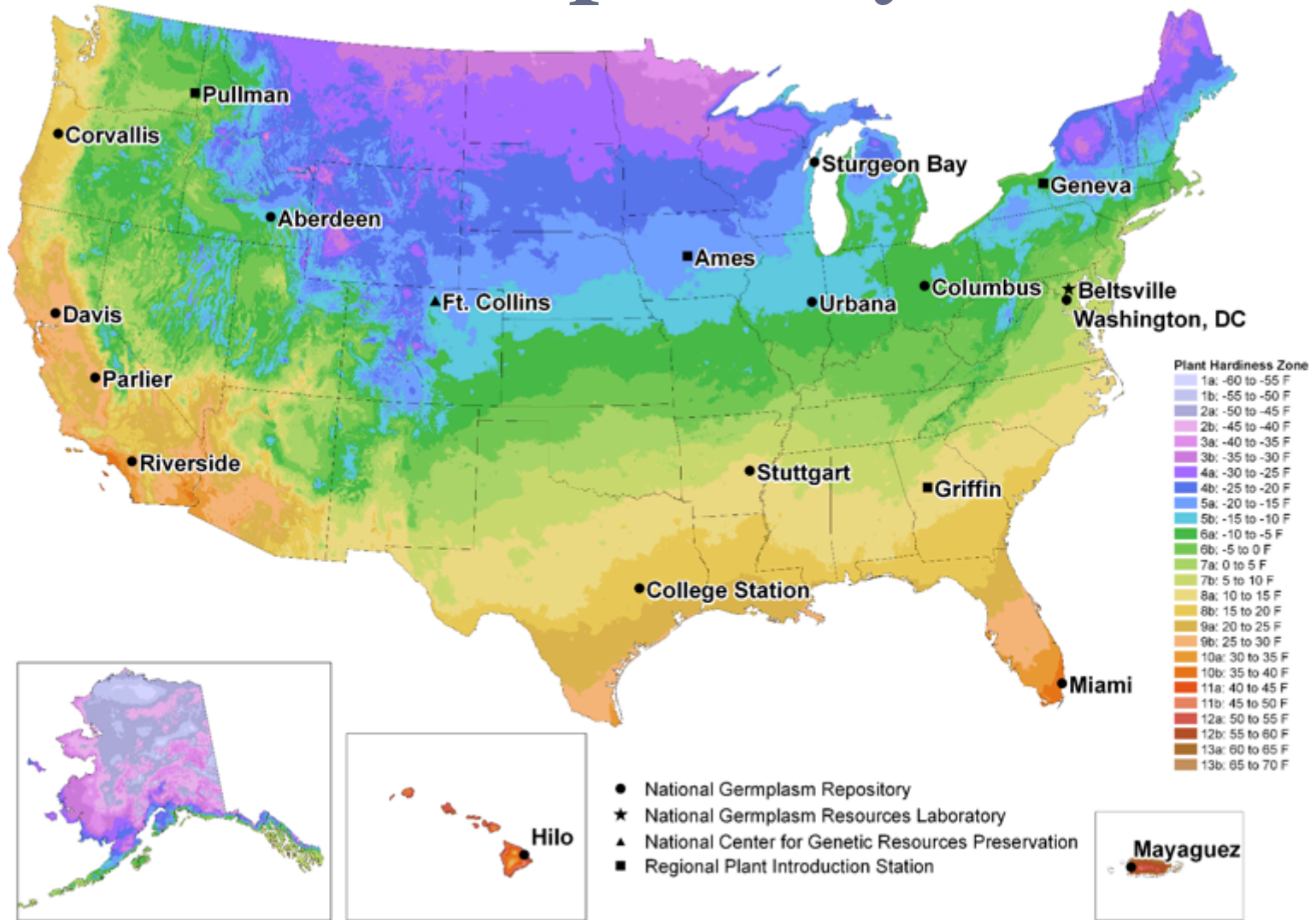
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National Plant Germplasm Repository System

- **A network of 29 repositories nationwide that preserve and regenerate seed and other reproductive tissues (germplasm) of plants and their wild relatives.**
- **More than 576,000 accessions comprising more than 2413 Genera, 219 families and 15130 species. >85 major crops (corn, wheat, etc.)**
- **One of the world's largest collectors and distributors of germplasm**
- **This public germplasm management system has yielded large economic benefits. U.S.A and worldwide**

NPGS Repository Locations





TROPICAL AGRICULTURE RESEARCH STATION (TARS)

- **FOUNDED IN 1901.**
- **BECAME PART OF THE AGRICULTURAL RESEARCH SERVICE (1961)**
- **PART OF THE U.S. NATIONAL PLANT GERMPLASM SYSTEM (NPGS) 1984**



TARS GERMPLASM COLLECTIONS

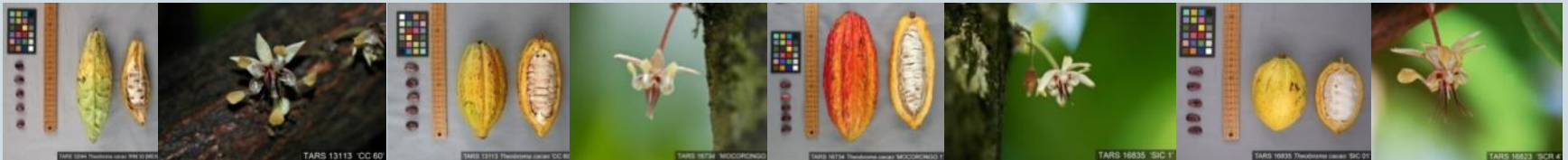


<i>Annona</i> spp.	17
<i>Artocarpus</i> spp (jackfruit, pana, pana pepita)	25
<i>Averrhoa carambola</i> (carambola)	12
<i>Bactris gasipaes</i> (peach palm)	3
<i>Dimocarpus longan</i> (longan)	11
<i>Durio zibethinus</i> (Durian)	3
<i>Garcinia</i> spp. (magosteen)	18
<i>Litchi chinensis</i> (lychee)	10
<i>Malpighia</i> spp. (Barbados cherry)	2
<i>Mangifera</i> spp. (mango)	50
* <i>Manilkara sapota</i> (sapodilla)	25
<i>Melicoccus bijugatus</i>	26
* <i>Musa</i> spp. (banana & plantain)	187
<i>Nephelium lappaceum</i> (rambutan)	9
* <i>Pouteria sapote</i> (mamey sapote)	28
* <i>Theobroma cacao</i> (cocoa)	211

Cacao collection



- *Theobroma cacao* L.
 - 211 accessions/clones (~1200) field RCBD
 - ✦ In the process of introducing ~50-100 accessions
- Breeding/selection programs Costa Rica, Ecuador, CRU, U. Reading, Brazil, Dominican Republic
- Evaluation and characterization
 - Horticultural/morphological
 - Molecular characterization
 - ✦ Microsatellites/SNPs












TARS 17834C  TARS
TARS 15
Field No. 94 Plant No. 3

<http://www.ars-gri.gov/>



<https://npgsweb.ars-grin.gov/gringlobal/view2.aspx?>

[dv=web_site_taxon_accessionlist¶ms=:taxonomyid=101885::siteid=7](https://npgsweb.ars-grin.gov/gringlobal/view2.aspx?dv=web_site_taxon_accessionlist¶ms=:taxonomyid=101885::siteid=7)

TARS 16652 *Theobroma cacao* 'HY 27 1420'





April 8th, 2008

1

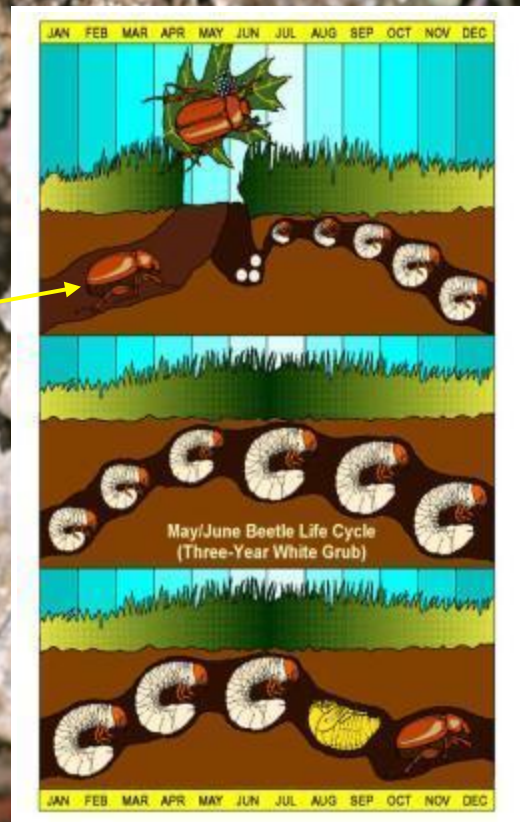
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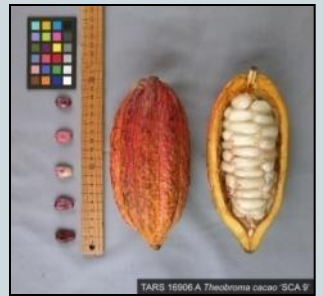
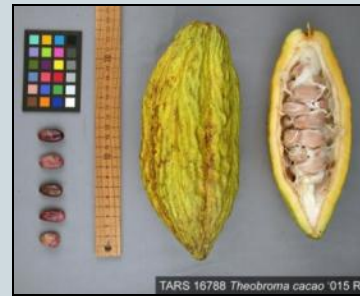
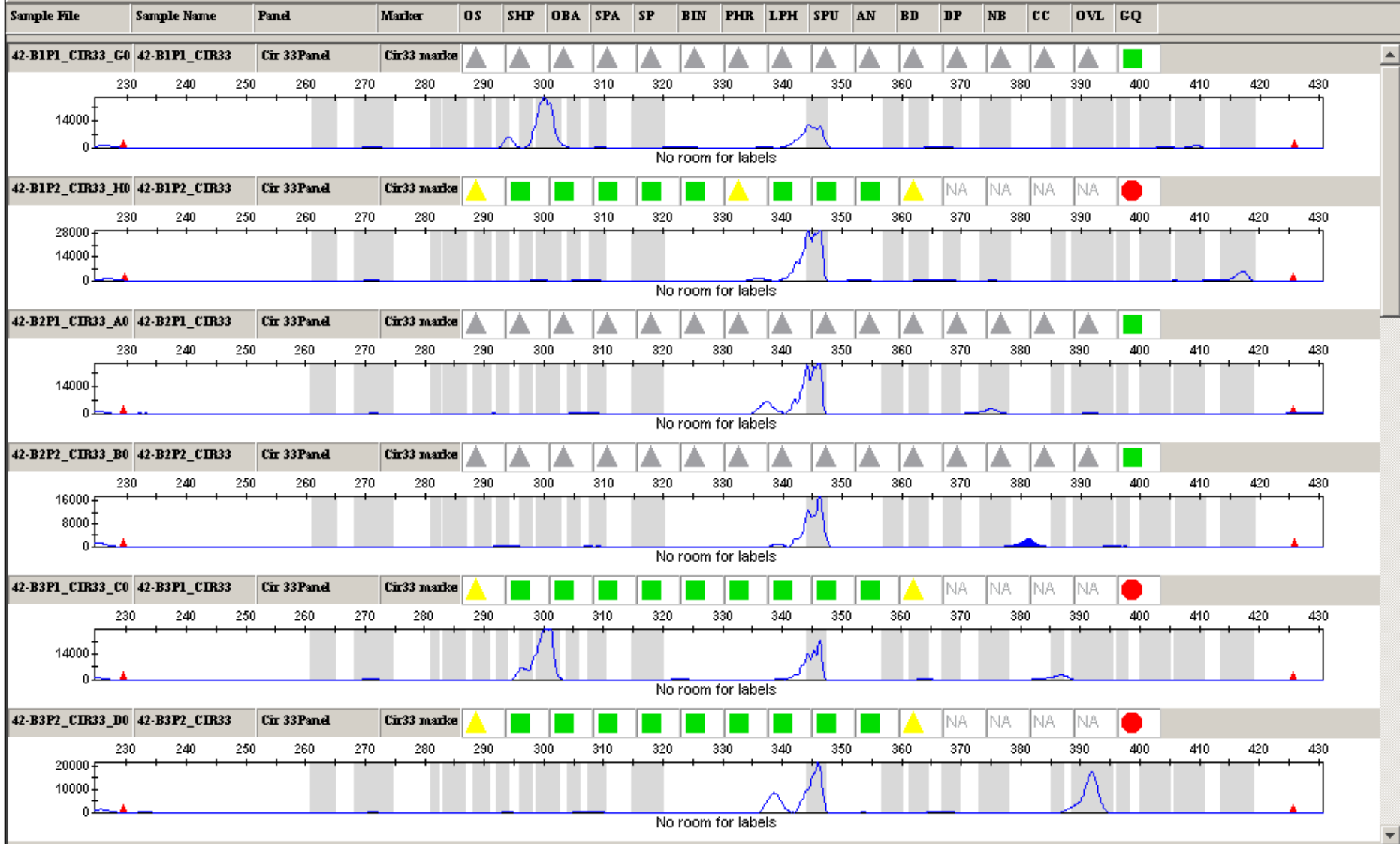




Table 3. Chocolate flavor profiles of nine cacao clones selected for high yield in Puerto Rico during a four-year harvesting period, 1994-1997.

Clone	Flavor profile of 65% chocolate
TARS -1	----- A very complex nut character comes through, more like chestnuts roasting with a blend of some hazelnuts skins.
TARS-9	----- Gorgeous color. Very smooth in flavor profile. Very mild chocolate notes up front with low overall bitterness and a distinct nut character that persists. Aftertaste has a residual nut / nut skins note. Really good chocolate.
TARS-14	----- Good base chocolate notes with a deep woody source. Slight earthy, woody and mushroom notes. Overall flavor comes off as quite good, very complex and very dark.
TARS-15	----- Very dark color. Early mild astringency with an interesting wood resin/floral note that comes through nicely. The late taste has an aldehyde, fruit character that is quite interesting. The continuing aftertaste of the chocolate is very notable. Complex floral/mild fruit note.
TARS-23	----- Rich, smooth chocolate profile up front with lots of deeper, mild dark wood notes. Really good overall flavor profile. The aftertaste is really a good chocolate.
TARS-27	----- Smoother flavor profile from the beginning with some very mild floral notes and some mild chocolate cocoa. Some mild spice notes along with slight flowers. The color is also a very attractive brown, lighter brown hue.
TARS-30	----- More of a woody late floral taste. Astringency comes back at the aftertaste.
TARS-31	----- Interesting fruit tartness along with some astringency and a complex mildly floral with tropical fruit notes.
TARS-34	----- Mild chocolate note with some mild fruit character. More of a fleshy yellow fruit flavor and some mild brightness. Acceptable flavor.

Clone #42-EET 53
Heterozygote/Homozygote





RIM 2 [MEX]



RIM 6 [MEX]



RIM 10 [MEX]



RIM 13 [MEX] A



RIM 2 [MEX]



RIM 15 [MEX]



RIM 34 [MEX]



RIM 41 [MEX]



RIM 48 [MEX]



RIM 52 [MEX]



RIM 75 [MEX]



RIM 105 [MEX]



P 10 [MEX]



P 22 [MEX]



P 43 [MEX]



EET 381



EET 353



SGU 69



RIM 13 [MEX] B



RIM 30 [MEX]

Single Nucleotide Polymorphism

- (SNP) cacao genotyping every plant in collection (~100 EST derived SNP loci)
- Using same set of SNPs to characterize naturalized cacao in PR

Accession name	1060	1159	139	150	151	189	193	230	329	364	372	534	591	702	75	799	90
SIC 72 A	CT	AC	GT	GT	CT	AA	AC	AG	AG	AG	AT	CT	AA	CC	CT	GT	AC
P10 [MEX] A	CT	AC	GT	●●	CT	AG	AC	AG	AG	AG	AT	●●	AA	CT	CT	GT	AC
RIM 41 [MEX]	CT	AC	GT	GT	CT	AG	AC	AG	AG	AG	AT	CT	AA	CT	CT	GT	AC
APA 4	CC	CC	GG	TT	CC	GG	AA	AA	GG	GG	AA	TT	AA	TT	TT	TT	CC
EET 64 [ECU]	CC	AC	GT	GT	CT	AG	AC	AA	GG	GG	AT	CT	CC	TT	TT	TT	AC
EET 381 [ECU]	CT	AC	GT	GT	CT	AG	AC	AG	AG	AG	AT	CT	AA	CT	CT	GT	AC
ICS 41	CT	AC	GT	GG	CT	AG	CC	AG	AG	AG	AT	CT	CC	CT	CC	GT	AC
ICS 39	CT	AC	GT	GT	CT	AA	AC	AG	AG	AG	AT	CT	AA	CC	CT	GT	AC
ICS 45	CT	AC	TT	GT	CT	AA	CC	AG	AG	AG	TT	CT	AA	CC	CC	GG	AC
TSH 1112	CC	AC	GT	GG	TT	AA	CC	AG	AG	GG	AA	CC	CC	TT	CT	TT	CC
EET 353 [ECU] B	CT	AC	GT	GT	CT	AG	AC	AG	AG	AG	AT	CT	AA	CT	●●	GT	AC
PENTAGONUM	CC	AC	TT	GT	TT	AA	AA	AG	AA	AG	AT	CT	AA	CT	CC	GG	AC
PA 303 [PER]	CC	CC	TT	GT	CT	GG	AA	AG	GG	GG	AA	CC	CC	CT	TT	TT	CC
CC 80	CT	AC	GG	GT	CC	AG	AC	AG	AG	AG	AA	TT	AA	CT	CT	TT	AC
ICS 95	CT	AC	GT	GT	CT	AG	AC	GG	AG	AA	AT	CT	CC	CC	CT	GT	AC
SIAL 44	CC	CC	GG	TT	CC	GG	AA	AA	GG	GG	AA	CT	AA	TT	TT	TT	CC
CC 11	CT	CC	GT	GT	TT	AG	AA	AA	AG	GG	AT	CT	AC	TT	CT	GT	CC
SGU 69	CT	AC	GT	GT	CT	AG	AC	AG	AG	AG	AT	CT	AA	CT	CT	GT	AC
UF 29	CT	CC	GT	GG	CC	AG	AC	AA	AG	GG	AA	CT	CC	CT	TT	TT	CC
COLORADO	CT	AC	GG	●●	CC	AA	AC	●●	AA	AA	AA	CC	CC	CC	TT	TT	AC
PA 121 [PER]	CC	CC	GT	GT	CC	GG	AA	AA	GG	GG	AA	CT	CC	CC	TT	TT	CC
SPEC 194/16	CC	AC	GT	GT	TT	AG	AA	AA	GG	GG	AT	CT	AC	CT	CT	GT	CC

The Puerto Rican Cacao Project

[Home](#)[Cacao In Puerto Rico](#)[About This Study](#)[Progress Map](#)[Contact Us](#)[Blog](#)

Cacao in Puerto Rico?



The Puerto Rico Federal Experiment Station (now known as TARS) has been introducing and studying important cacao genetic resources since the early 1900s.

According to Seguire's article *Cocoa Genetics and Breeding* featured on *The Manufacturing Confectioner*, cacao took on commercial value when a confectioned chocolate drink had been taken back to the court of Spain.

After the Spanish colonization, 'New World' agricultural crops, including cacao and cacao planting material were taken along their trade routes. Cacao began to move within the Caribbean regions from Central America and northern South America to islands including Puerto Rico.

Chocolove[®]
X O X O X

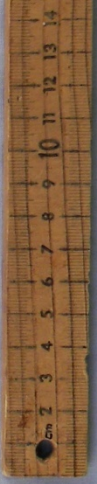
The first significant commercial production of cacao was in Brazil. Historical evidence shows that by 1665, ginger and cacao had become two of the most important export crops in Puerto Rico. However, by the end of the 17th century, a hurricane caused major damage to the island's agriculture and destroyed many cacao plantations. Damage to the agricultural sector from the storm caused food shortages and farmers had to abandon cacao.

What is Cacao?

Cacao, whose proper scientific name is *Theobroma cacao* (Derived from the Greek theos meaning god and broma meaning food, food of the gods) is the main source for chocolate confection.







COLUMBANO 2

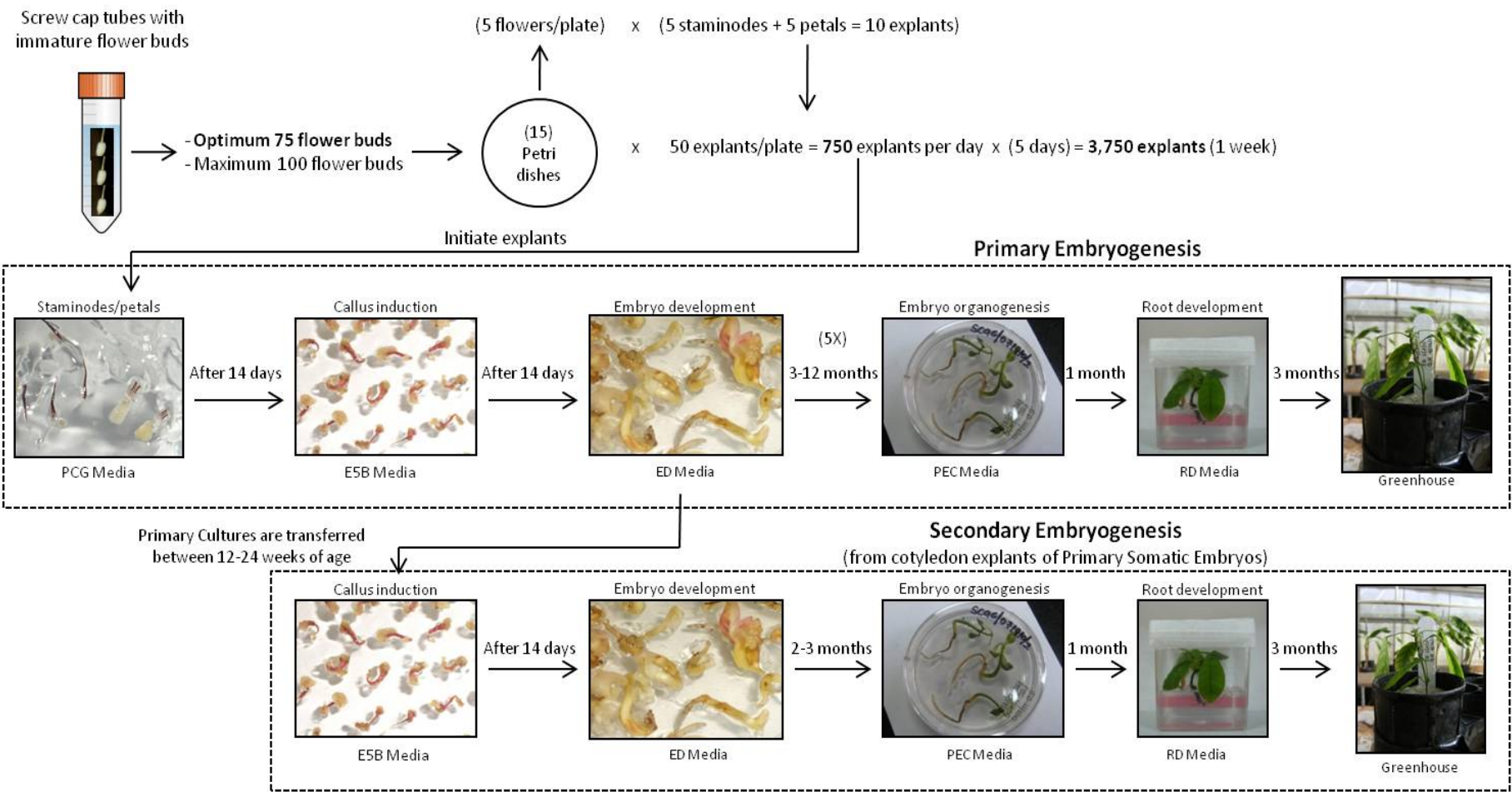


COLUMBANO 1



Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Google
Image Landsat

Google earth



Summary (for one week of initiating plants)

- A. For Primary Embryogenesis at a rate of 3,750 explants plated in one week, the number of greenhouse acclimated plants after 8-14 months could approximate **20,000**. This is because at the ED medium step at least 5 somatic embryos (5X) can be recovered from each callus explant.
- B. Secondary Embryogenesis (10-12 months) multiplication rate depends of quantity of Primary Embryo Cultures that are transferred. Multiplication rate (rate of embryo development) rate is higher for the Secondary Embryogenesis process than it is for the Primary embryogenesis process.
 - For example - From 3 Petri dishes with primary embryos cultures 80 secondary embryos can be generated in a two month period vs. 80 primary embryos obtained in a six month period.

Media abbreviations
 PCG = Primary callus growth
 E5B = Secondary callus growth
 ED = Embryo development
 PEC = Primary embryo conversion
 RD = Root development

Figura 1. Esquema del proceso de multiplicación de cacao vía embriogénesis somática con números teóricos basados en producción óptima con el clone 'SCA 6'.



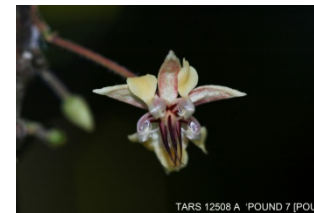
DECEMBER 2009

GRAFTED

SE



Theobroma cacao – back up



- Seed cryopreservation was attempted
 - High fatty acid content not good (desiccation)
- Gultinan et al. have established somatic embryogenesis (SE) protocols
- At TARS SE is being used for multiplication of specific genotypes as well as for medium and long-term storage
 - SE is very genotype specific
 - Shoot preservation and micro-grafting





TARS 17836 - 'TARS 27'

- Selección local de semilla híbrida - Cosa Rica
- Padres: 'EET-400' x 'SCA-12'
- Producción
 - # mazorcas por árbol por año: **57**
 - Índice de mazorca: **29**
 - *Producción: ~**2,560** lbs./cuerda
- *(prácticas y distancias de siembra en TARS):
- Propiedades organolépticas
 - Suave, notas florales, color marrón claro
- Compatibilidad
 - **Auto-compatible?**



*Promedio mundial = 440 lbs./cuerda

* En TARS podemos los arboles bien bajos, tenemos alta densidad, cosechamos solo una vez al mes, tenemos riego, abonamiento. Todo esto influye en la productividad.

TARS 17832 - 'TARS 9'

- Selección local de semilla híbrida - Cosa Rica
- Padres: 'EET-400' x 'SCA-12'
- Producción
 - # mazorcas por árbol por año: **31**
 - Índice de mazorca: **27**
 - *Producción: ~**1,544** lbs./cuerda
- *(prácticas y distancias de siembra en TARS):
- Propiedades organolépticas
 - Color precioso
 - Muy suave, poco amargo, con sabor a nueces, muy buen chocolate
- Compatibilidad
 - **Auto-compatible?**



TARS 17832 *Theobroma cacao* 'CACAO TARS 9'

TARS 16734 - 'COLORADO'

- Origen desconocido
- Producción
 - # mazorcas por árbol por año: **25**
 - Índice de mazorca: **35**
 - * Producción: ~**924** lbs./cuerda
- *(con nuestras practicas y distancias de siembra):
- Propiedades organolépticas
 - Uno de los mejores de calidad organoléptica con sabores a fruta (cítrica y perfume de flores)
- Compatibilidad
 - **Auto-compatible?**



TARS 16734 *Theobroma cacao* 'Colorado'

TARS 16668 - 'ICS 45'

- Selección 'Criollo'
- Oriundo/Trinidad – serie ICS
- Producción
 - # mazorcas por árbol por año: 12
 - Índice de mazorca: 35
 - * Producción: ~607 lbs./cuerda
- * (con nuestras practicas y distancias de siembra):
- Propiedades organolépticas
 - Sabores muy suaves, sedoso
- Compatibilidad
 - **Auto-compatible?**



TARS 16668 *Theobroma cacao* 'ICS 45'

Different agroenvironments early cacao clones (36) (PR, HI)



Compatibility



	R	1	2	3	4	5	6	7	8	9	10
	Amelonado	TARS 27	TARS 30	TARS 23	TARS 14	TARS 9	TARS 34	SPA 10	RIM 52	COLORADO	ICS 45
R	Amelonado	2/15	6/20	0/20	7/20	0/9		1/10	0/20	2/20	0/2
1	TARS 27	0/11	5/14	4/15	10/19		0/2		3/23	7/11	
2	TARS 30		0/20	2/4					1/2		
3	TARS 23			0/20					0/2		
4	TARS 14				0/20						
5	TARS 9					0/16					
6	TARS 34						0/12				
7	SPA 10							1/20	3/5		
8	RIM 52					0/2			0/20		
9	COLORADO			1/8	6/12		1/2	1/6	5/18	0/20	
10	ICS 45										0/20

ACCESSION NAME: TARS 27 (PI 668456 CACAO TARS 27)

Self Pollinations

	Flower	Female identifier	Male identifier	Covered date	Polliantion date	Julian date	Flower fall	Julian date	DAP	
1	1	plant#3	plant#2	09/23/14	09/24/14	267	09/29/14	272	5	
	2	plant#3	plant#2	09/23/14	09/24/14	267	10/06/14	279	12	
	3	plant#3	plant#2	09/23/14	09/24/14	267		342	75	
	4	plant#3	plant#2	09/23/14	09/24/14	267		342	75	
	5	plant#4	plant#2	09/23/14	09/24/14	267	09/29/14	272	5	
	6	plant#4	plant#2	09/23/14	09/24/14	267		342	75	
	7	plant#4	plant#2	09/23/14	09/24/14	267		342	75	
	8	plant#4	plant#2	09/23/14	09/24/14	267		342	75	
	9	plant#4	plant#2	09/23/14	09/24/14	267		342	75	
	10	plant#3	plant#3	09/29/14	09/30/14	273	10/14/14	287	14	
	11	plant#3	plant#3	09/29/14	09/30/14	273	10/28/14	301	28	
	12	plant#4	plant#4	09/29/14	09/30/14	273		342	69	
	13	plant#3	plant#4	11/17/2014	11/18/14	322		342	20	
	14	plant#3	plant#4	11/17/2014	11/18/14	322		342	20	
	15	plant#4	plant#4	11/17/2014	11/18/14	322		342	20	
	16	plant#3	plant#4	12/02/14	12/03/14	337		342	5	
	17	plant#3	plant#4	12/02/14	12/03/14	337		342	5	
	18	plant#4	plant#4	12/02/14	12/03/14	337		342	5	
	19									0
	20									0





THANKS, GRACIAS Any ?