Exploración y aprovechamiento de la diversidad del banano para el desarrollo de variedades con resistencia a enfermedades limitantes

Fernando A. García-Bastidas PhD

Líder programa mejoramiento Banano– KeyGene

Wageningen - Netherlands

@Ferchucky

fba@Keygene.com

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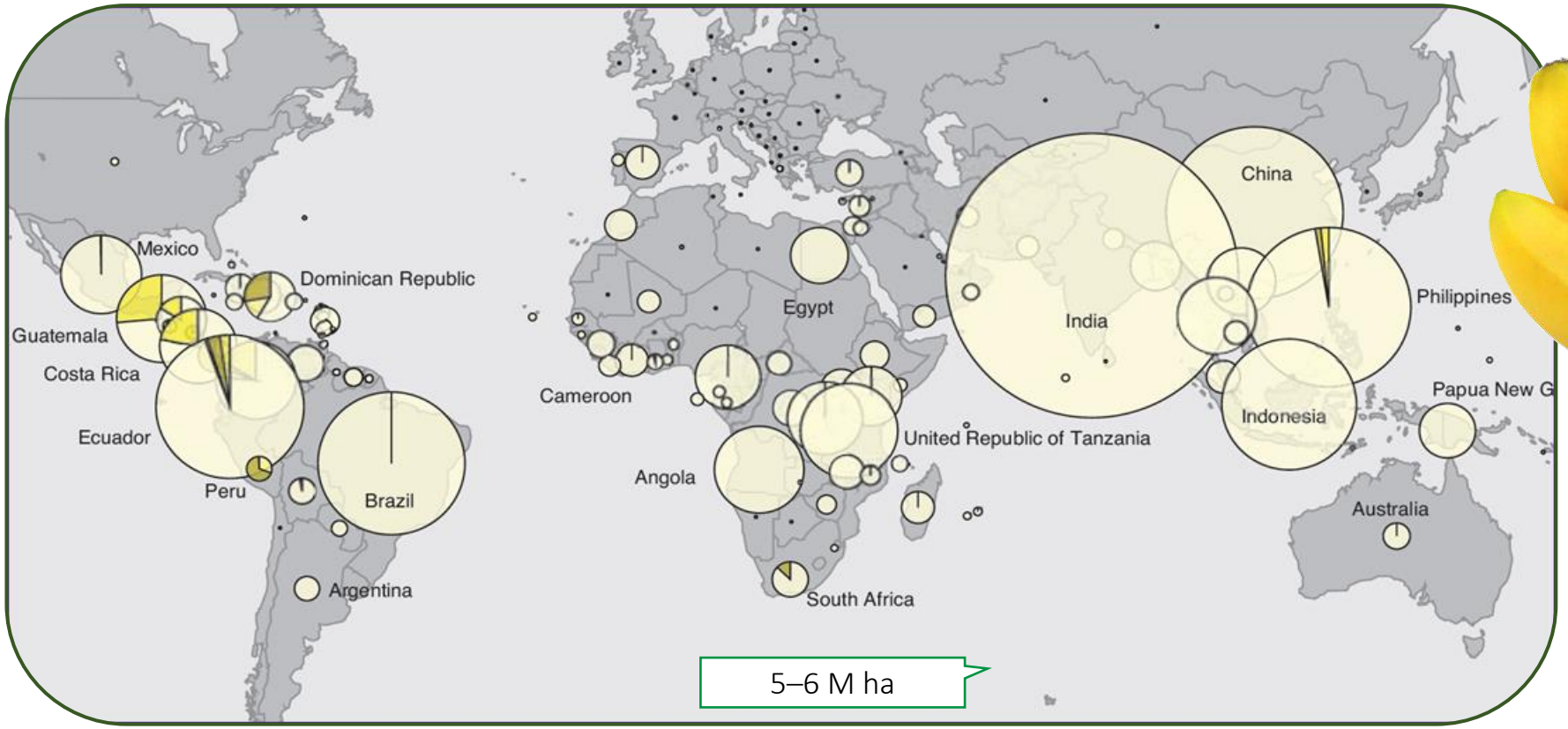
Cavendish

- ‘Grand Naine’
- ‘Williams’
- ‘Valery’
- ~ 50 more….

Cavendish – global monoculture



Diversidad Genética

Heslop-Harrison J. S. & Schwarzacher T. 2007

Mas de 1200 variedades

650 Cultivares triploides

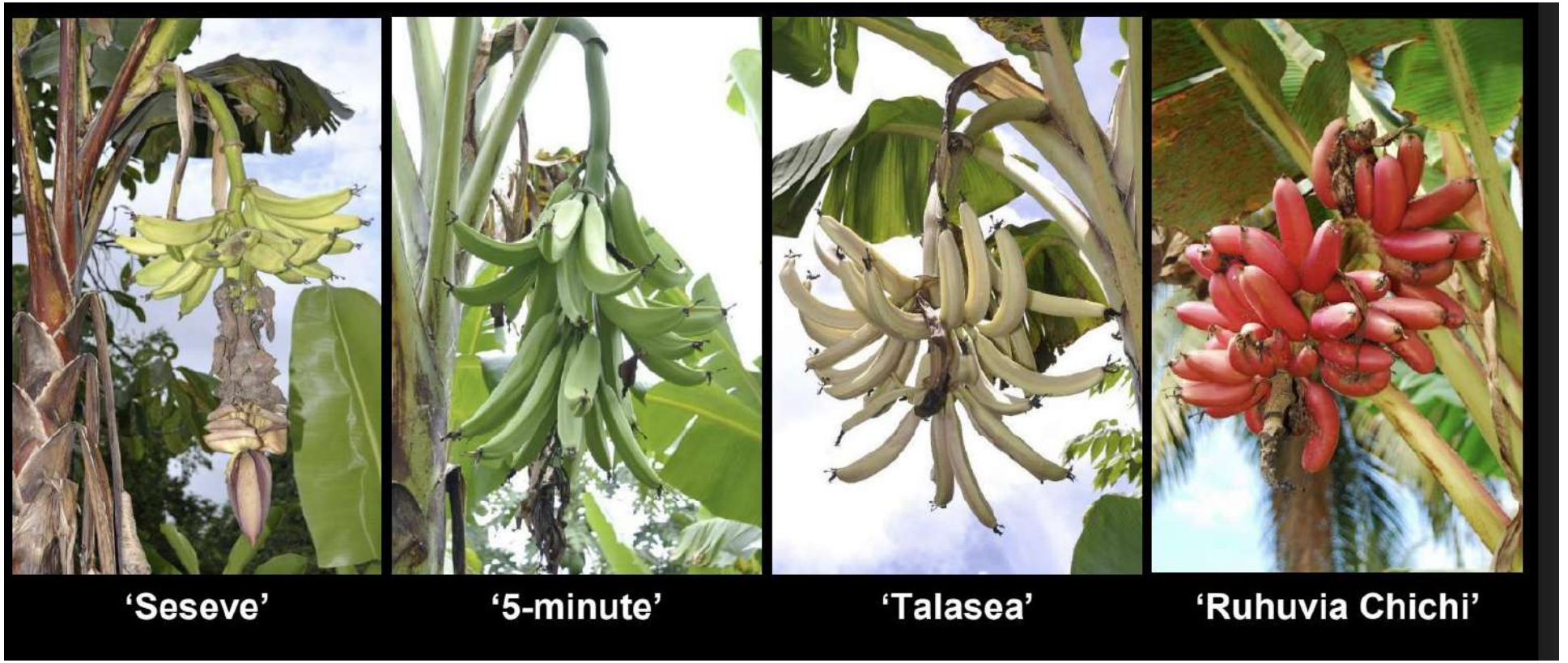
290 Cultiaves diploides

Híbridos ???

180 especies silvestres

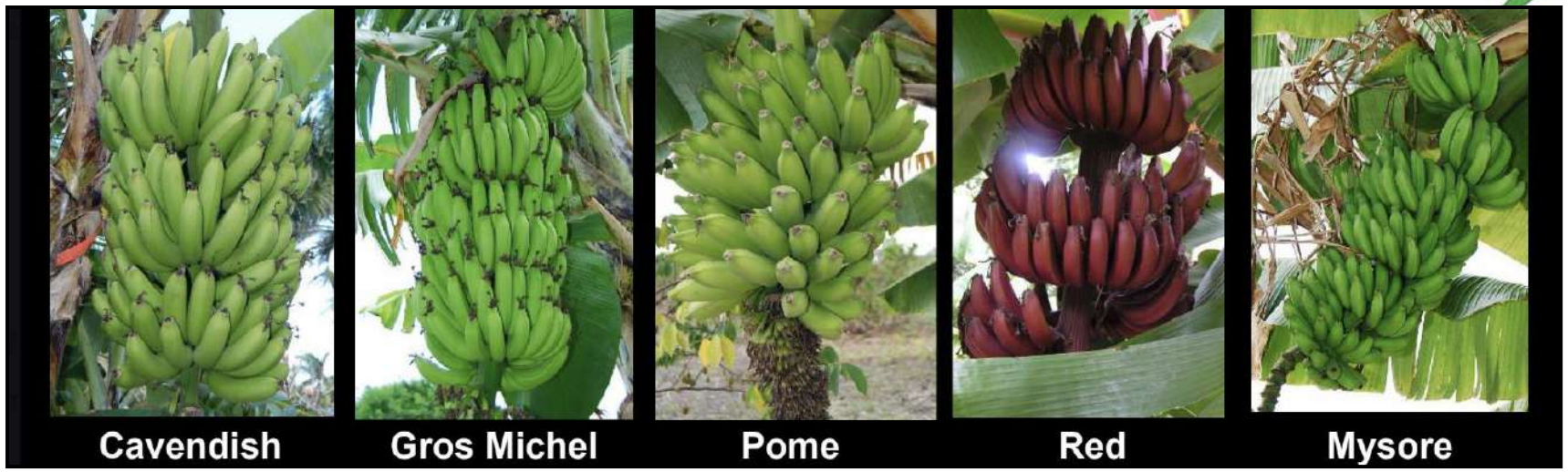
Lescot., 2019

Diploides Comestibles



Photos by Smith GS

Triploides



Photos by Smith GS

Diploides Silvestres

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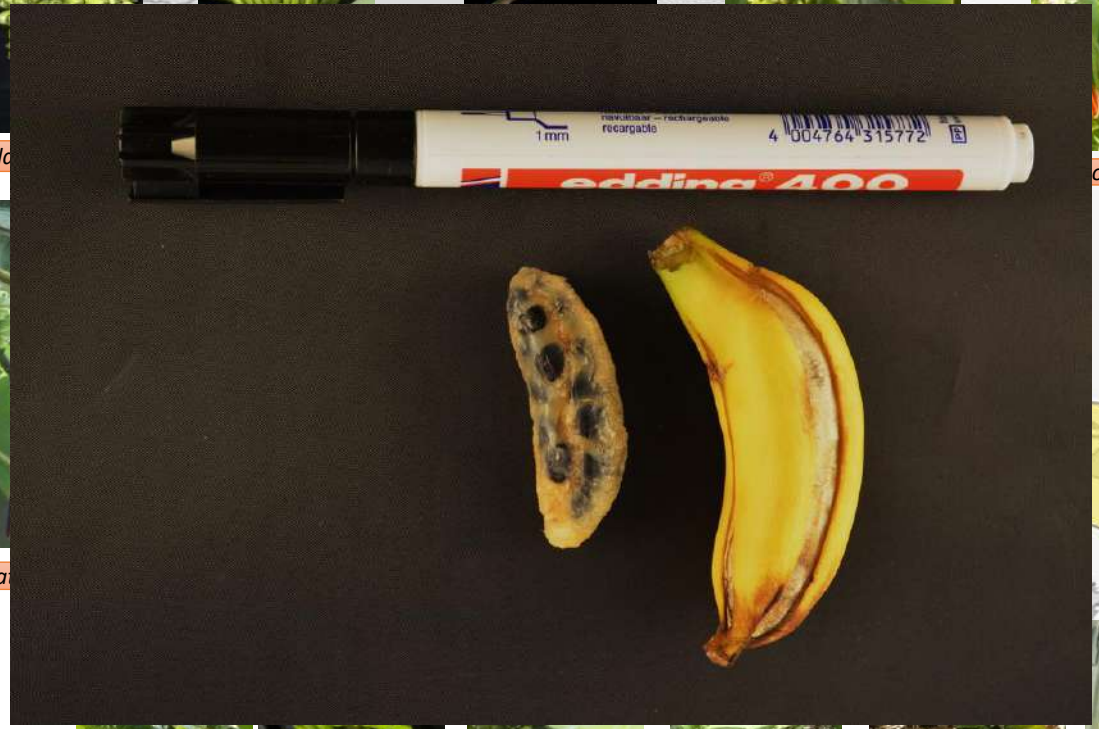
halo

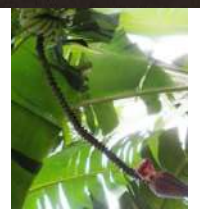
ome



longipetiola

malaccensis

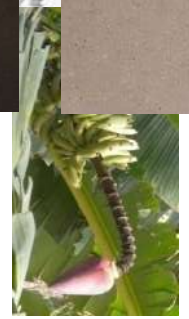
zebrina



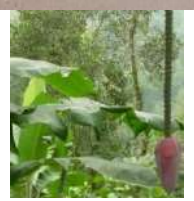
breviformis

cerivera

bantamensis



nakaii



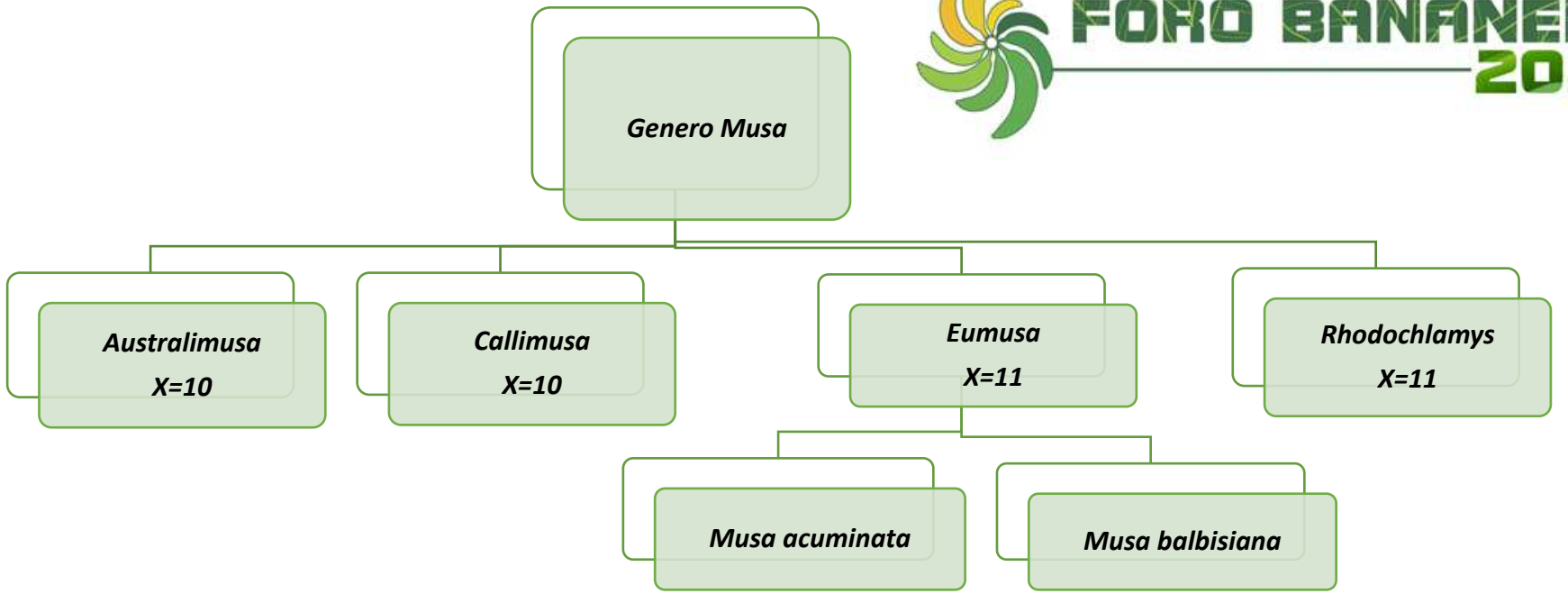
rutilifes

KeyGene

Photos by Fajar Ahmad – F. García Bastidas

Genus

Section



Musa textilis

Domestication
Edible clones : Fe'is

Musa beccarii

Musa acuminata

Domestication
Edible banana varieties

Musa balbisiana

Musa velutina

Bakry et al., 2009

Musa acuminata (AA)

X

Musa balbisiana (BB)

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Pisang Mas (AA)

Cavendish (AAA)

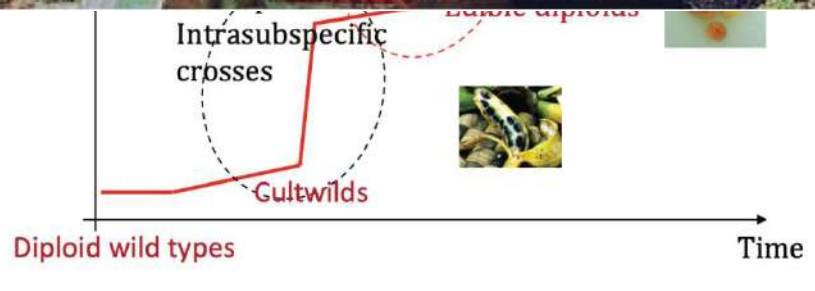
Kepok (ABB)

AB, ABB, AAAA, ABBB….

Maryani ., 2019

Domesticación

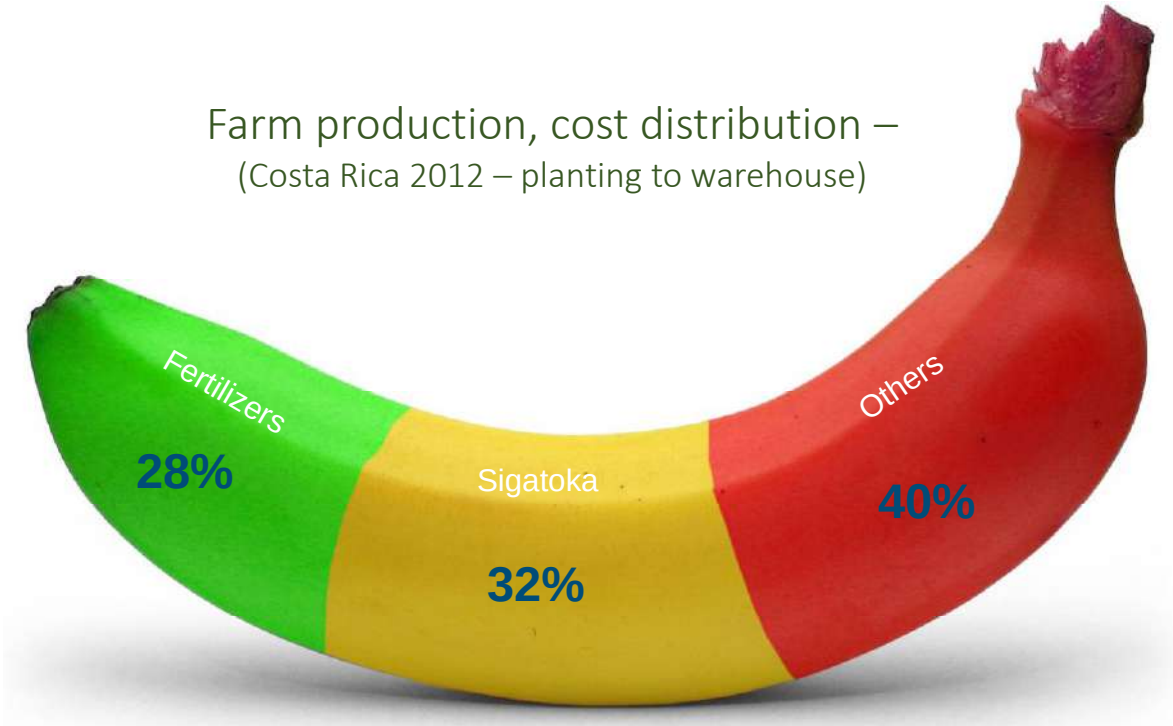
#TheHistoryOfTheBanana



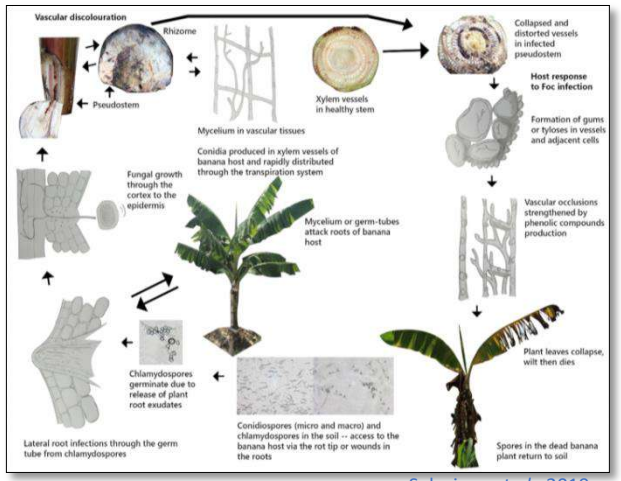
5000
B.C

Cavendish & la producción sostenible
Bajo amenaza

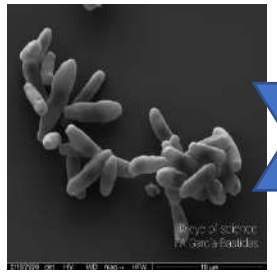
Black Sigatoka (*Pseudocercospora fijiensis*)

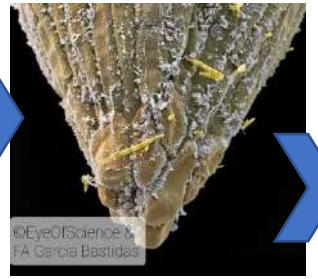


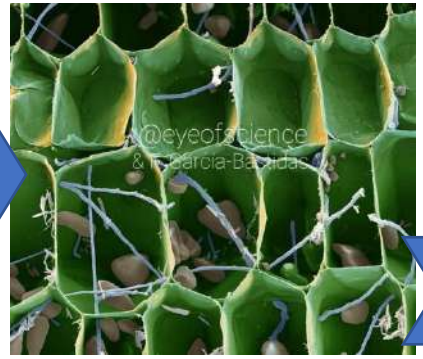
Amenaza TR4



Salacinas *et al*., 2019





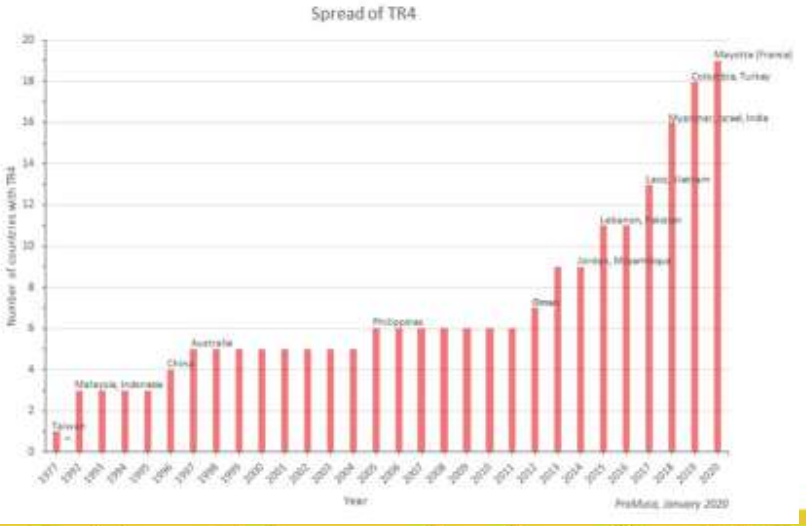


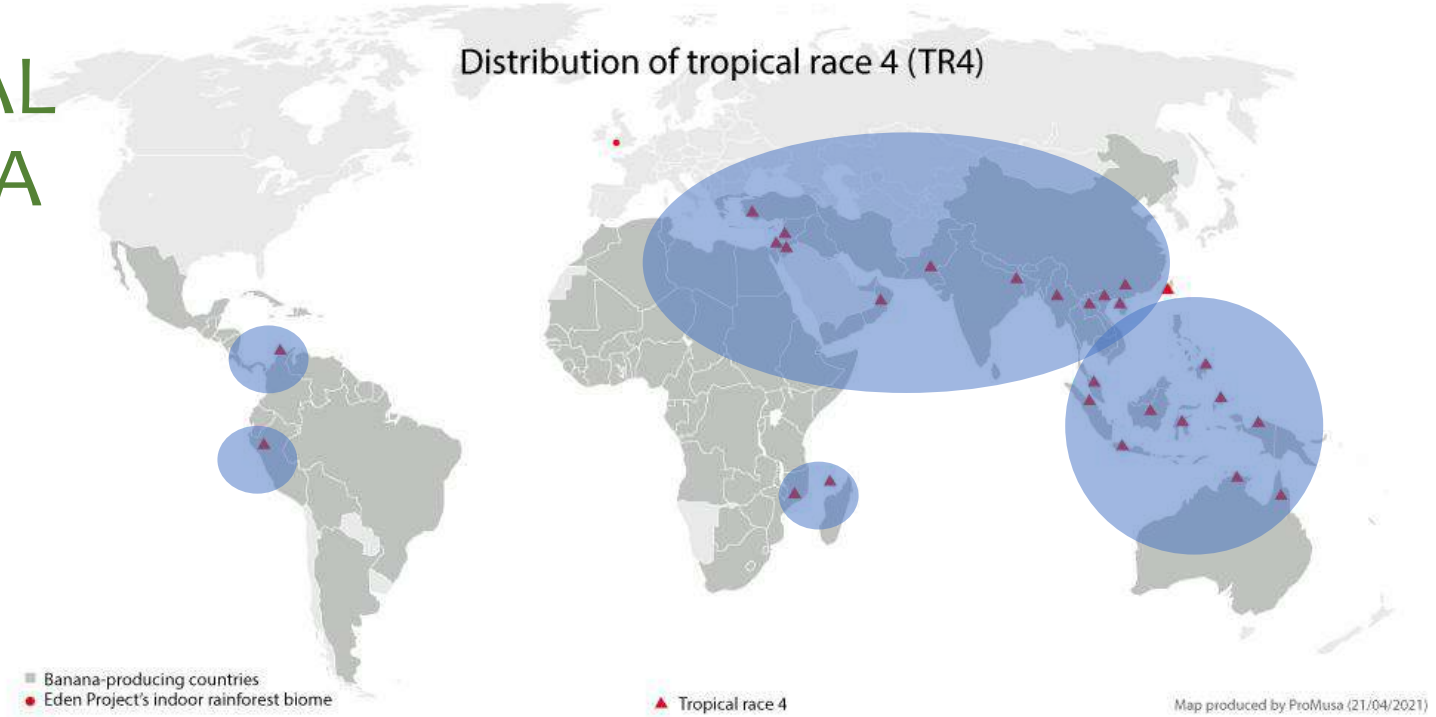
FUSARIUM RAZA 4 TROPICAL DE PROBLEMA LOCAL A UNA PANDEMIA

Mal de Panamá versión 2.0
Tropical Race 4
Cavendish = Susceptible

2013 (5 países) – 2022 (>20 países)

1990 ——— 2022





Jorge Hernan Palacino, ICA 2020

Fotos: ICA Twitter 2020

Que hacer?


PANAMA DISEASE
IN BANANA
Spread, Screens and Genes
Fernando A.
García-Bastidas

~~Control~~ =Management

Escenario 1

ario 2

- Genotipos pre-existentes

- Mejoramiento Clásico
- Mejoramiento no convencional
  - Mutagénesis
  - GM - GE

Resistencia de la colección global de Musáceas (banana y plátano) contra *Fusarium* spp. Race 1 y TR4

Panama Disease in Banana: Spread, Screens, and Genes, García., 2019

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UNIVERSITY & RESEARCH

Improved protocols

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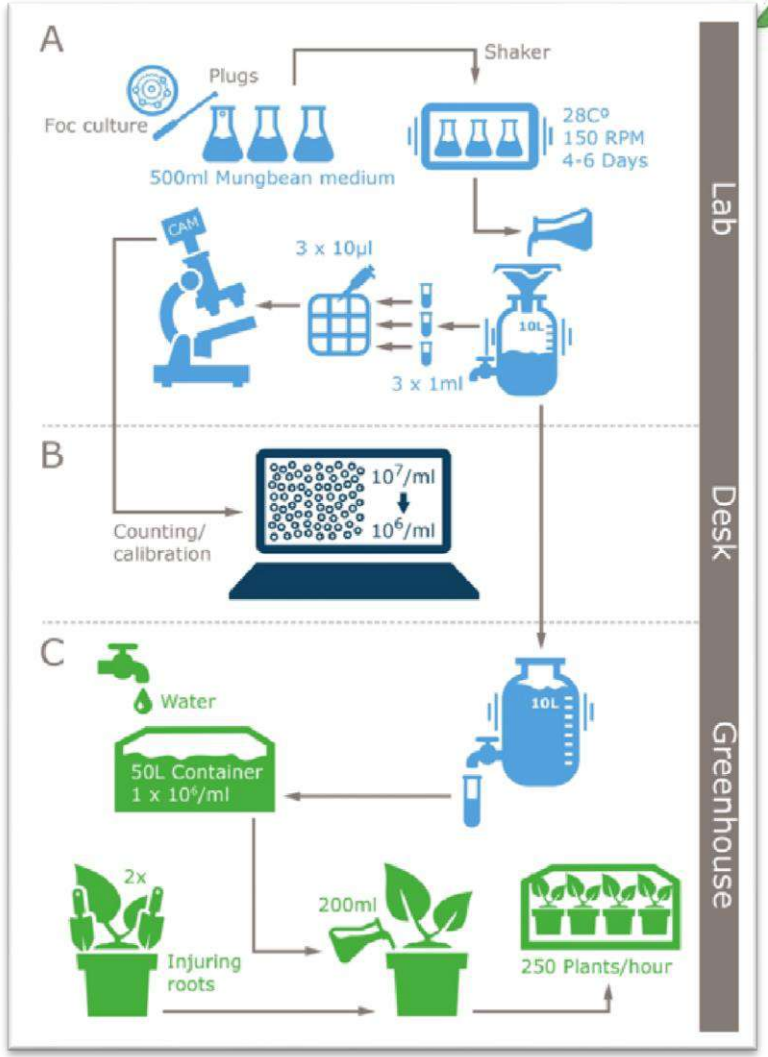

García-Bastidas *et al*, 2019

Method for Fusarium sporulation (Panama Disea…

Evaluation of Banana Plants for Resistance to Tropical…

YouTube

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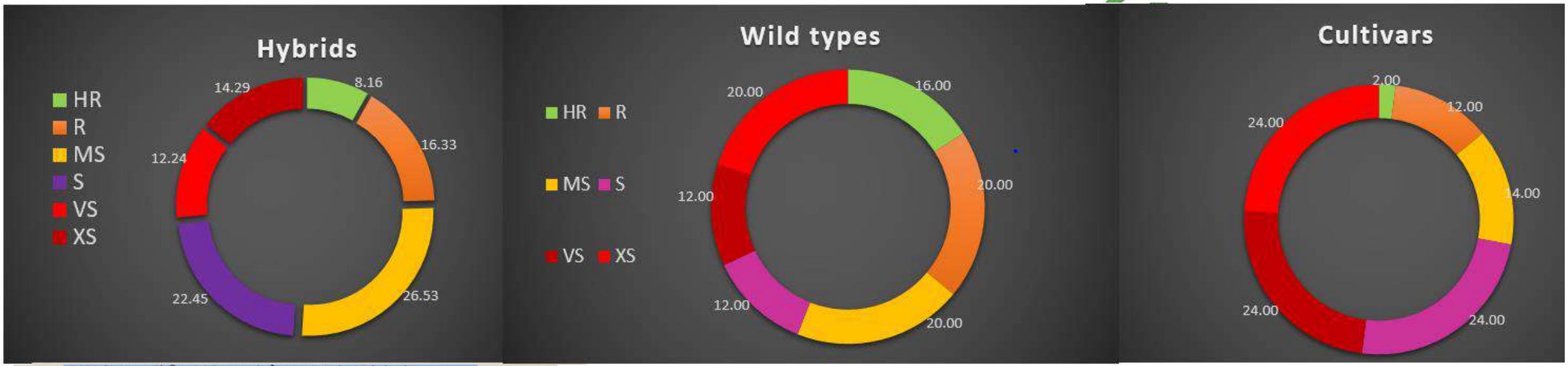
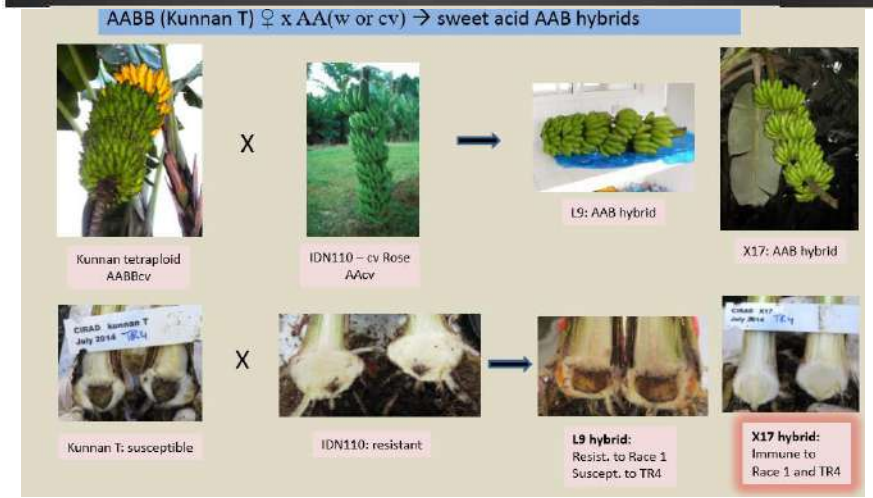
FORO BANANERO 2022

Screenings for resistance (R1-TR4)





García-Bastidas F, Bakry F, Irish B & Kema K. 2019

Bioversity International · USDA · Queensland Government Department of Agriculture and Fisheries · cirad Agricultural Research for Development · INISAV Instituto de Investigaciones de Sanidad Vegetal

WAGENINGEN
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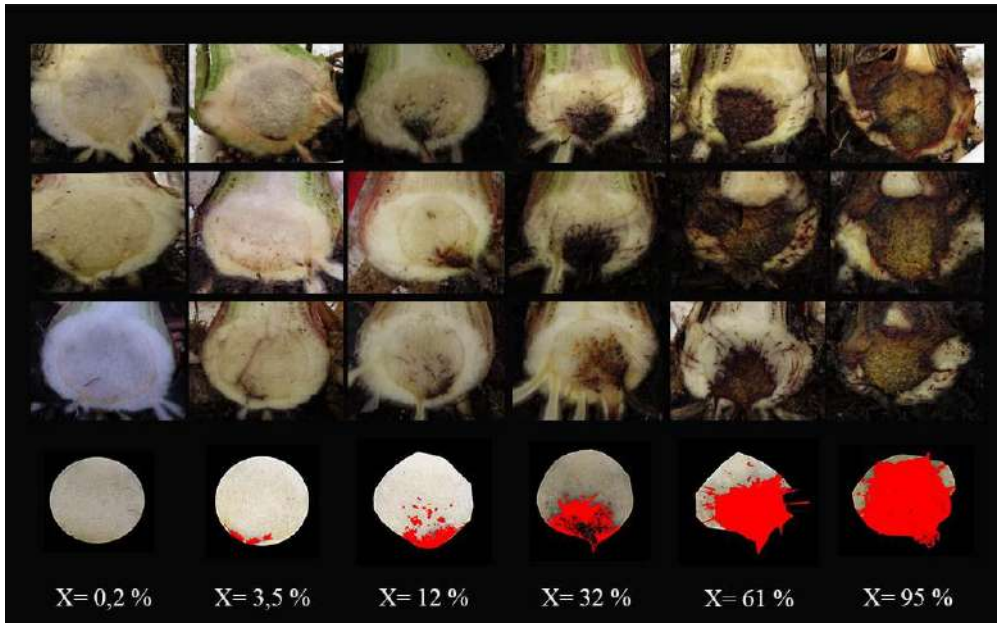
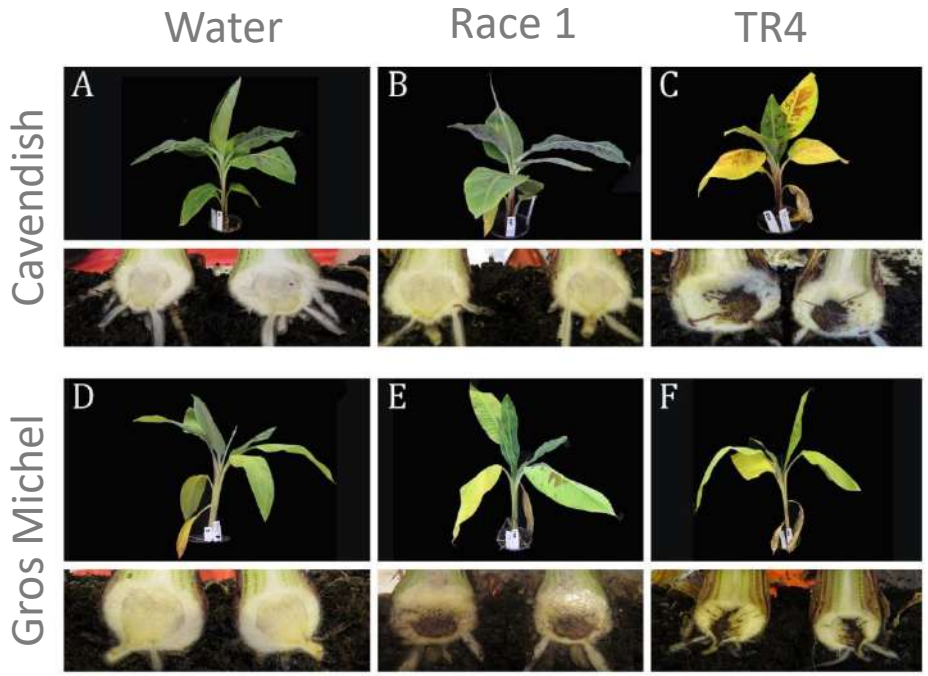
FORO BANANERO 2022

DIFERENTIAL FUSARIUM WILT DISEASE REACTION OF BANANA (*MUSA* SPP.)



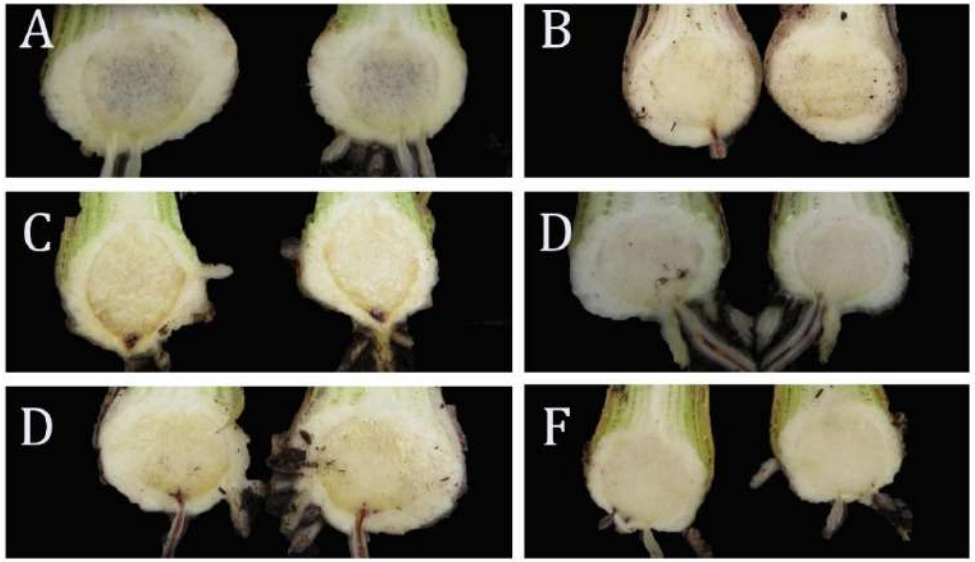
R MS S



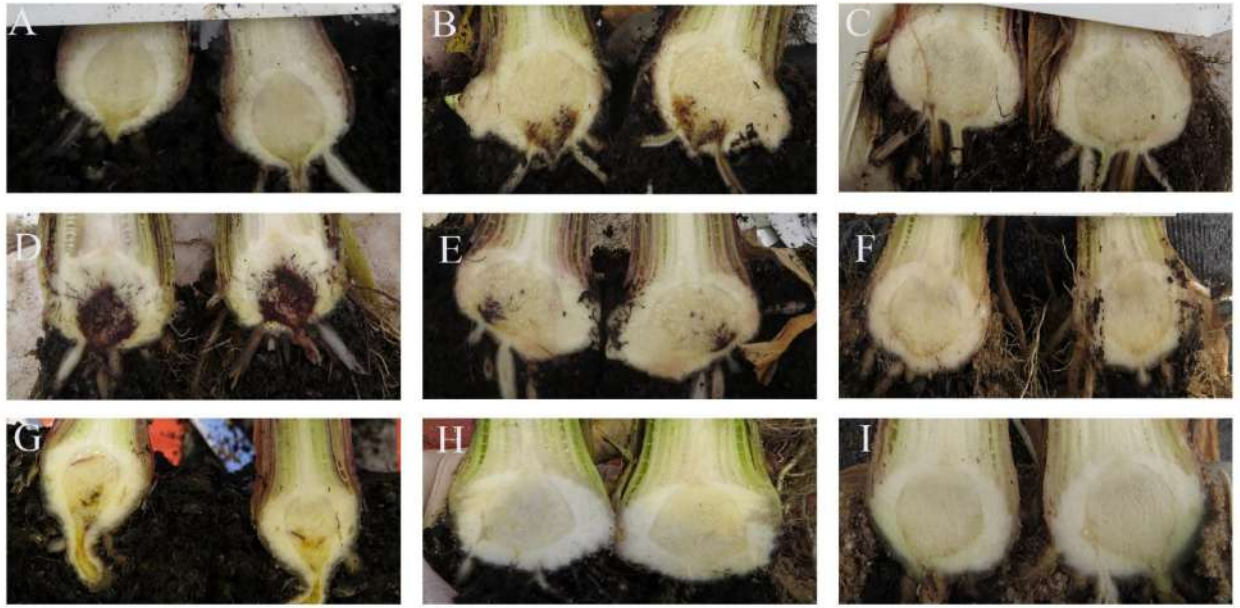
Differential responses of banana cultivars 'Grand Naine' and 'Gros Michel' after inoculation with race 1 and TR4.

Panama Disease in Banana: Spread, Screens, and Genes, Garcia., 2019

DIFERENTIAL FUSARIUM WILT DISEASE REACTION OF BANANA (*MUSA* SPP.)



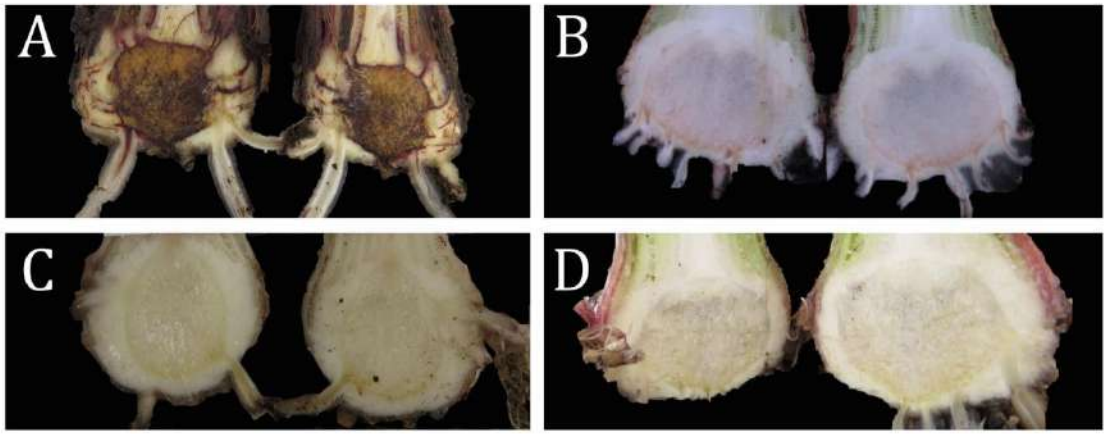
(A) 'Morong Princesa'; (B) 'Uwati'; (C) 'NBA-14'; (D) 'Manang'; (E) 'Paka'; and (F) 'Tjau Lagada'.



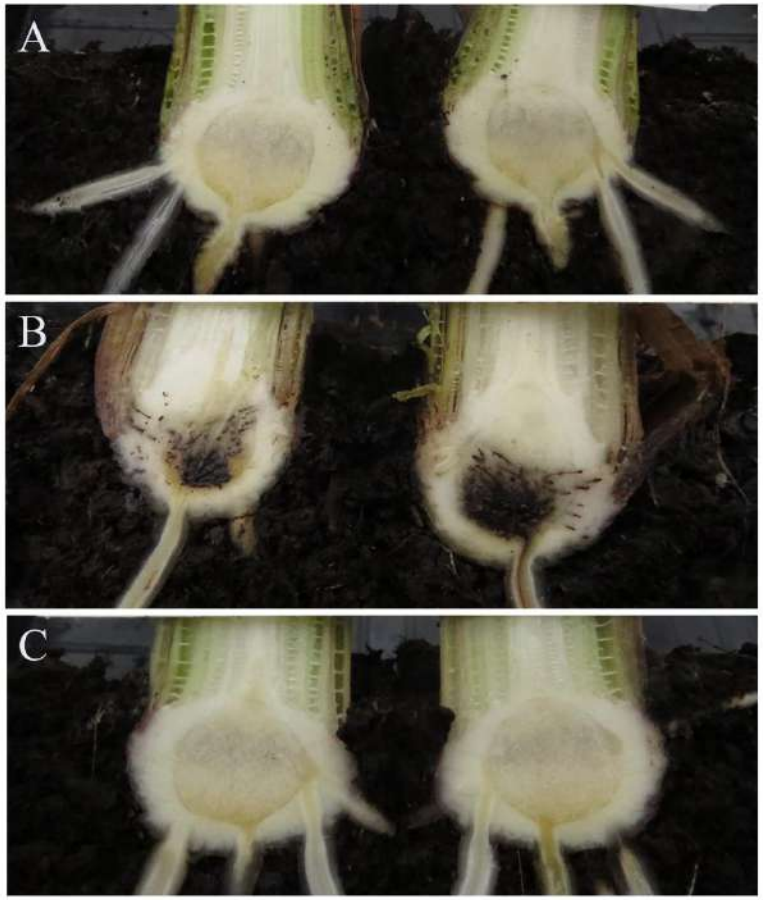
(A), Cavendish-Somaclone 'Dwarf Nathan'-; (B), Cavendish-Somaclone GCTCV-119; (C), AAA-Red 'Verdin'; (D), East African Highland Banana (EAHB) 'Nchumbahaka' AAA – 'Mutika' ; (E) Cavendish-Mutant 'M13'-AAA; (F) AAB plantain 'Dwarf superplantain'-; (G), Cavendish-mutant 'Gal'; (H), AAA Mutika EAHB 'Igitsiri (intuntu)'; (I), AAB plantain Congo 300-.

Panama Disease in Banana: Spread, Screens, and Genes, García., 2019

DIFERENTIAL FUSARIUM WILT DISEASE REACTION OF BANANA HYBRIDS



Differential Fusarium wilt disease reaction of resistant hybrid and susceptible banana (*Musa* spp.)



Water

Race 1

TR4

Panama Disease in Banana: Spread, Screens, and Genes, García., 2019

FORO BANANERO 2022

yelloway
the banana breeders

KeyGene

Chiquita

MusaRadix

135 accessions

AAA ABB AAB
Wild types (AA – BB)
Edible diploids (AA)

Crop Innovation Center

KeyGene

The crop innovation company

Precision breeding

FORO BANANERO 2022

~130 diploids

Bagul
Beram
Galeo

banksii

Spiral
Guyod
vudu beo
guyod
katuai

Microcarpa

Siamea
burma

Mlali

khai
figue

buaya

malaccensis

Zebrina

Gros Michel

Cavendish

Exploit existing genetic variation of 2n banana germplasm to develop novel edible, export, disease resistant banana varieties

Detailed Sequence of Cavendish + DNA profile of diploid germplasm

Knowledge based breeding

Comparing Genomes
(re)-constructing edible bananas (with Disease Resistance)

Germplasm Access & Management

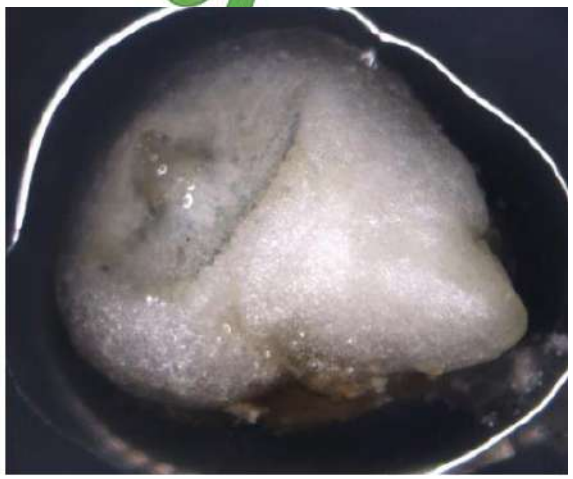
R&S-genes → 2n & 4n R-germplasm → 3n hybrids & fieldtrials → Diversity & varieties

Research Strategy


@Ferchuckygarcia

De semilla a planta

Embryo rescue



Padres mejorados
Resistencia (Fusarium y BS)

Poblaciones para estudios genéticos

Plantas resistentes

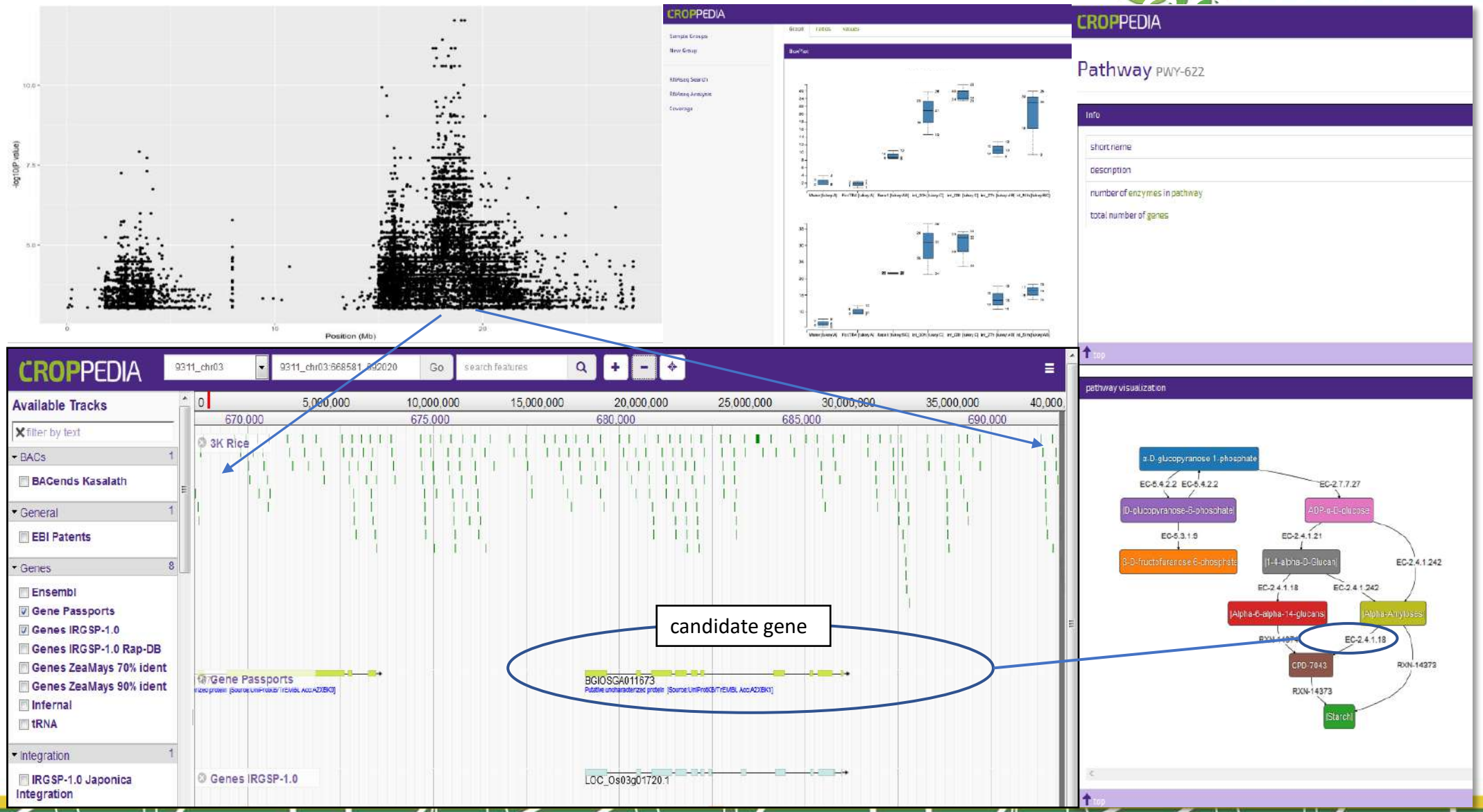
External view of the plant

Internal observation

Plantas susceptibles

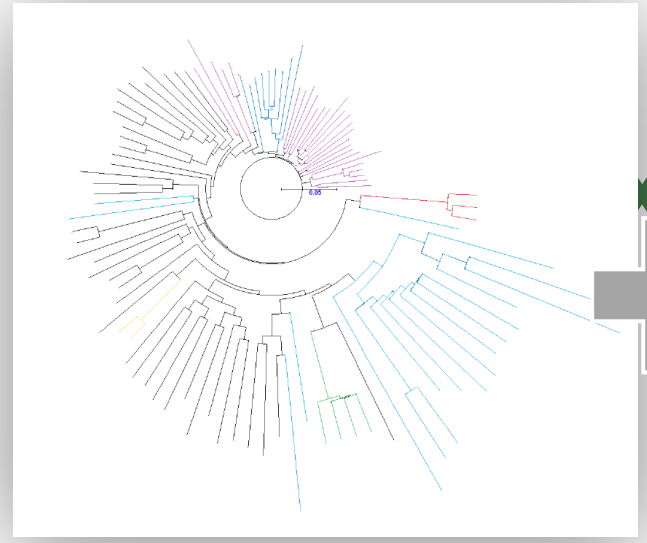
External view of the plant

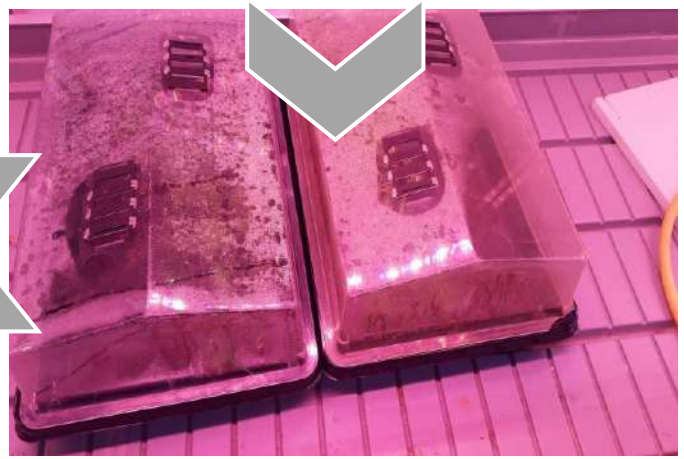
Internal observation

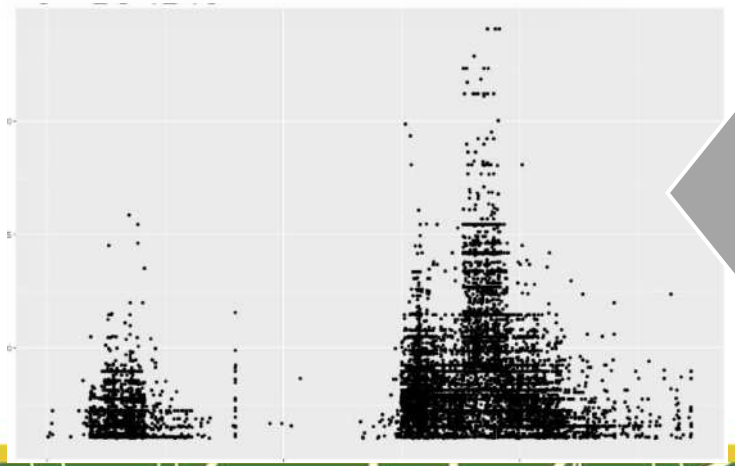

CROPPEDIA
Pathway PWY-622
Info
short name
description
number of enzymes in pathway
total number of genes
pathway visualization
9311_chr03
Go
search features
Available Tracks
filter by text
BACs
BACends Kasalath
General
EBI Patents
Genes
Ensembl
Gene Passports
Genes IRGSP-1.0
Genes IRGSP-1.0 Rap-DB
Genes ZeaMays 70% ident
Genes ZeaMays 90% ident
Infernal
tRNA
Integration
IRGSP-1.0 Japonica Integration
3K Rice
Gene Passports
Genes IRGSP-1.0
BGIOSGA011673
LOC_Os03g01720.1
candidate gene
a-D-glucopyranose 1-phosphate
b-D-glucopyranose-6-phosphate
ADP-a-D-glucose
b-D-fructofuranose 6-phosphate
[1-4-alpha-D-Glucan]
[Alpha-6-alpha-14-glucans]
[Alpha-Amyloses]
CPD-7043
[Starch]
EC-5.4.2.2
EC-2.7.7.27
EC-5.3.1.9
EC-2.4.1.21
EC-2.4.1.242
EC-2.4.1.18
RXN-14373

SA FOR TR4

Genotyping +phenotyping



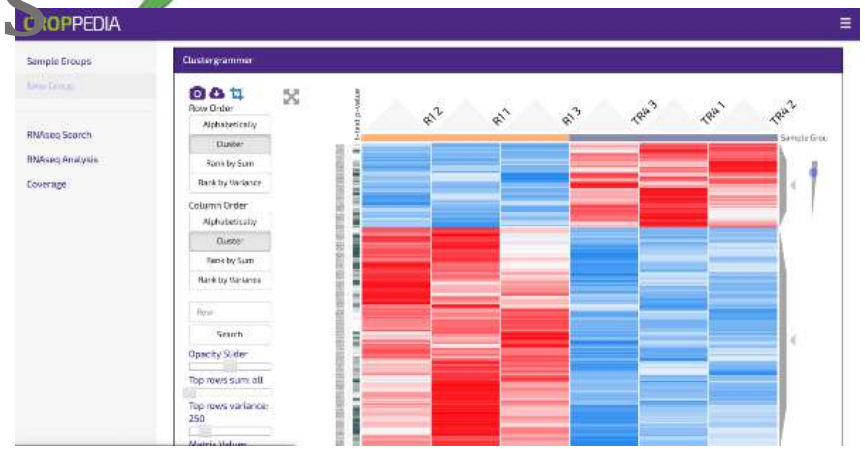




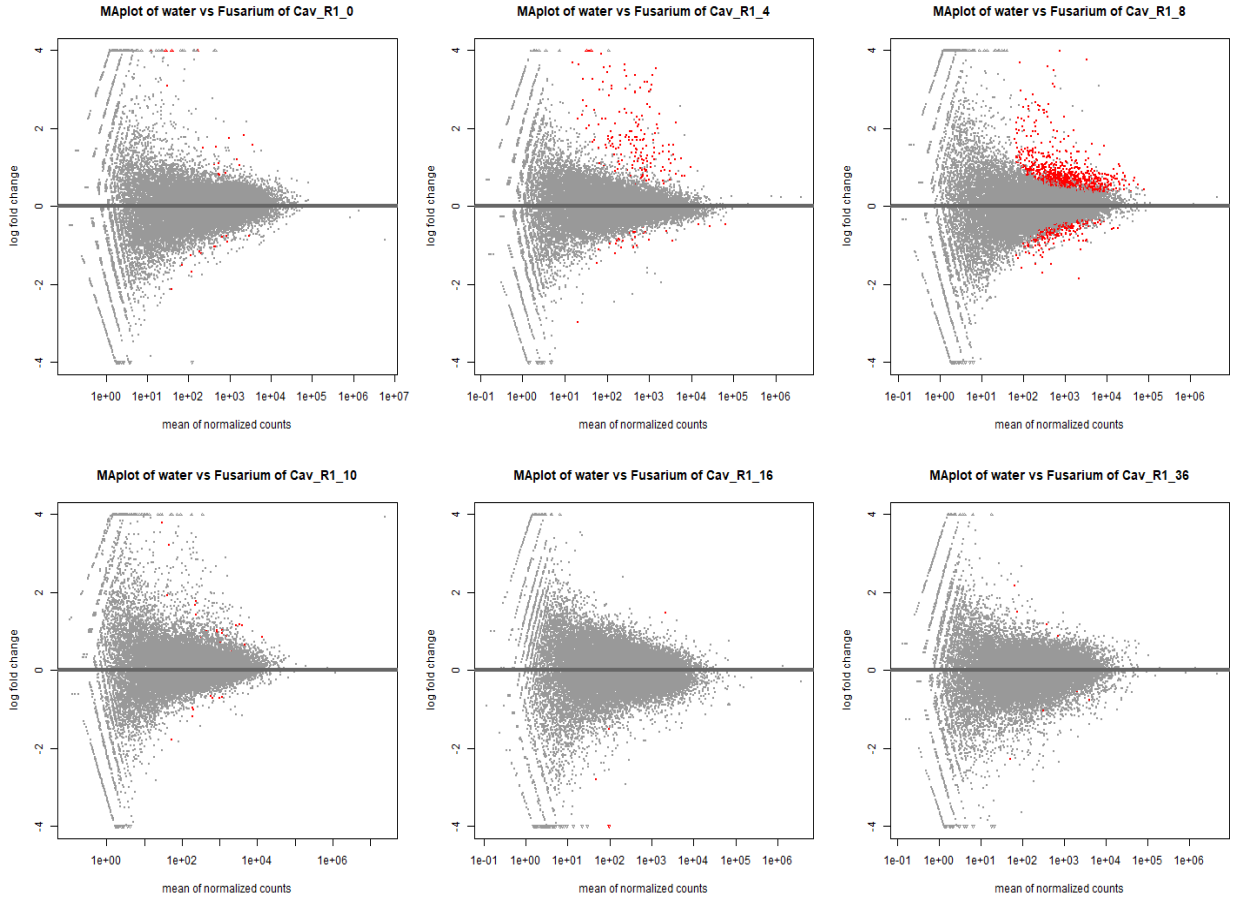
MusaPedia & KeySeeQ® analysis

Fusarium
Race 1

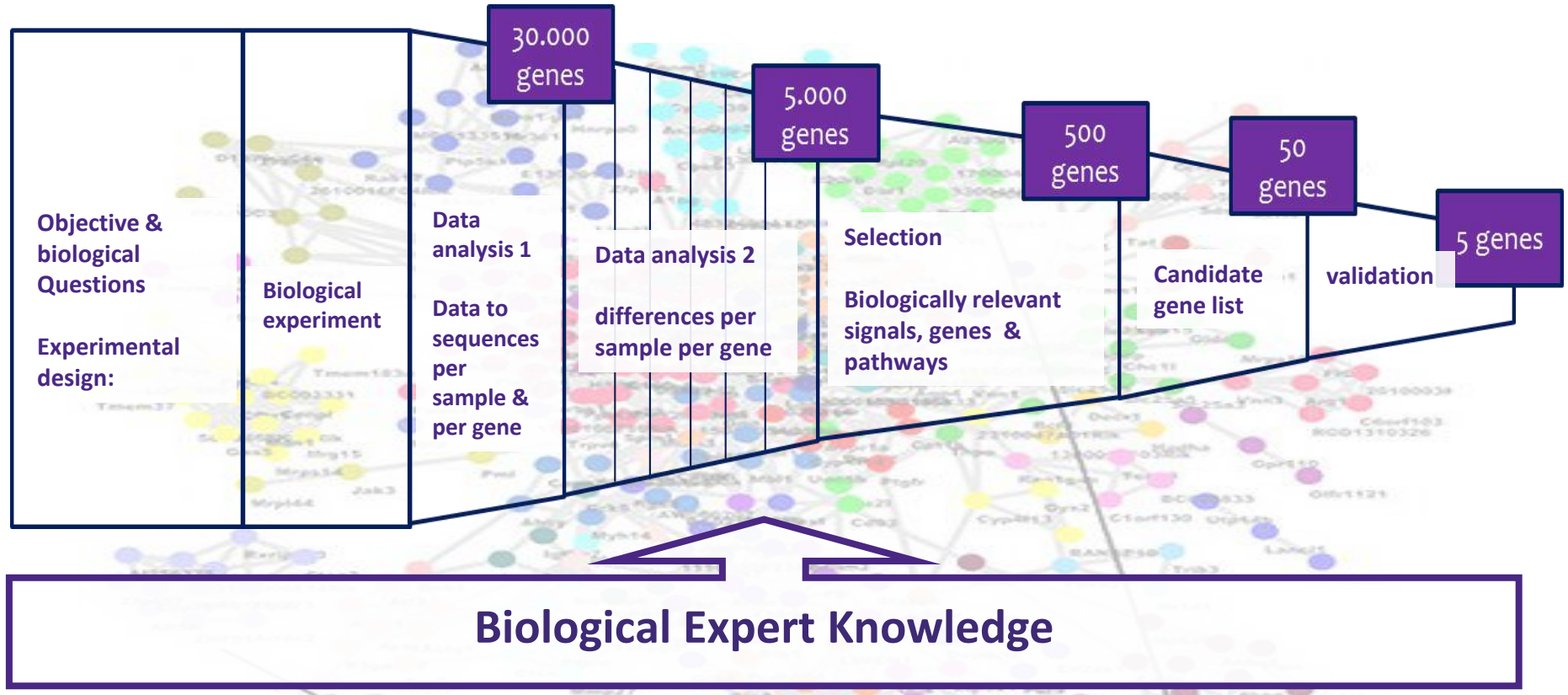
Fusarium
Tropical
Race 4



Differential gene expression – Resistant reaction

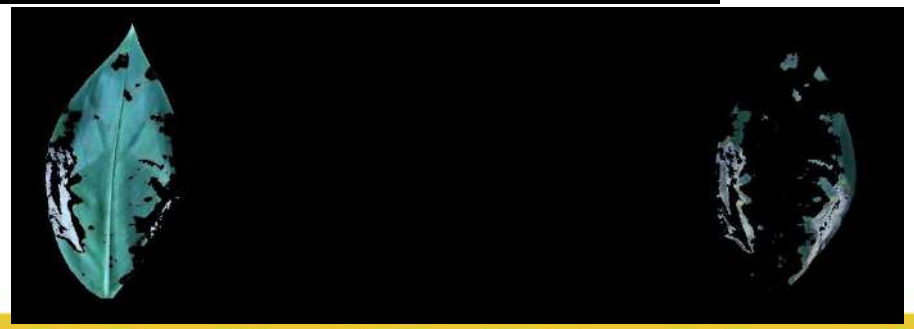


KeySeeq® -Transcriptomics based discovery



El futuro

Black Sigatoka - *P. fijiensis*



Isolate code	source	Symptoms development
P06	Costa Rica	+++
P45	Colombia	+++
P78	Africa (Zanzibar)	+++++
P122	Philippines	+
P132	Taiwan	+++
P134	Dominicans	+
P83	Panama	+++
P86	Taiwan	++

MUTANTS GM & GENOME EDITING

KeyPoint® Breeding: Random mutagenesis: sequence based detection of mutations

GE: Efficient protoplast regeneration protocols for banana

ARTICLE

DOI: 10.1038/s41467-017-01670-6 OPEN

Transgenic Cavendish bananas with resistance to Fusarium wilt tropical race 4

James Dale[1], Anthony James[1], Jean-Yves Paul[1], Harjeet Khanna[1,5], Mark Smith[2], Santy Peraza-Echeverria[1,6], Fernando Garcia-Bastidas[3], Gert Kema[3], Peter Waterhouse[1], Kerrie Mengersen[4] & Robert Harding[1]

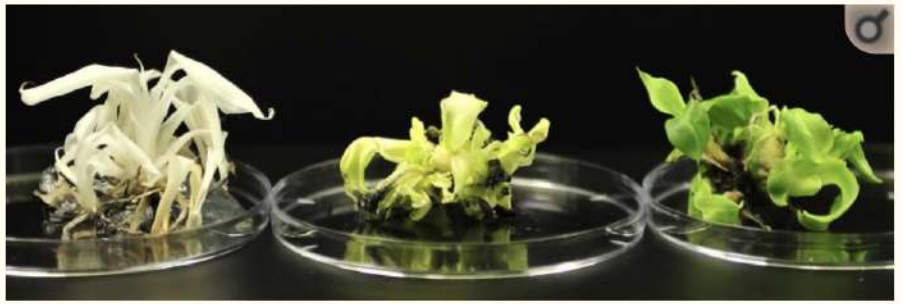
Transgenic Research

October 2018, Volume 27, Issue 5, pp 451–460 | Cite as

Gene editing the phytoene desaturase alleles of Cavendish banana using CRISPR/Cas9

Authors Authors and affiliations

Fatima Naim, Benjamin Dugdale, Jennifer Kleidon, Anthony Brinin, Kylie Shand, Peter Waterhouse, James Dale



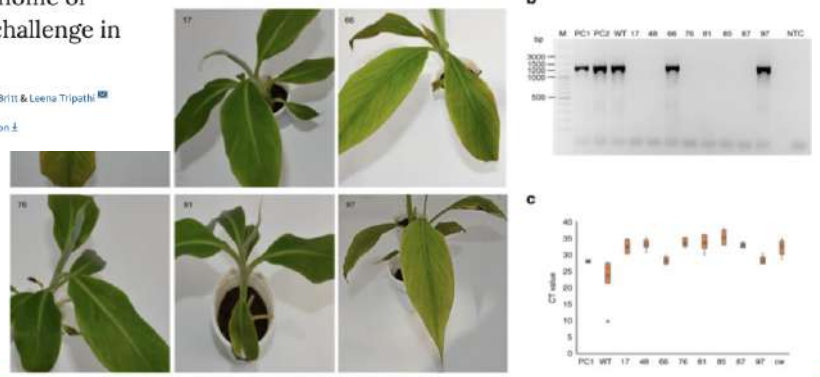
COMMUNICATIONS BIOLOGY

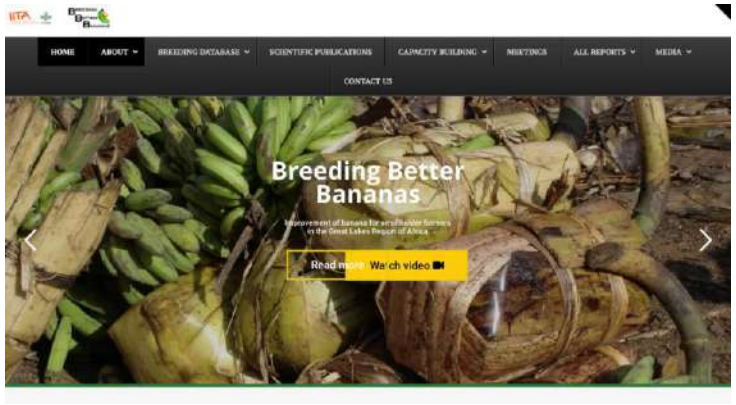
Article | OPEN | Published: 31 January 2019

CRISPR/Cas9 editing of endogenous *banana streak virus* in the B genome of *Musa* spp. overcomes a major challenge in banana breed

Jaindra N. Tripathi, Valentine O. Ntui, Mily Ron, Samwel K. Muiruri, Anne Britt & Leena Tripathi

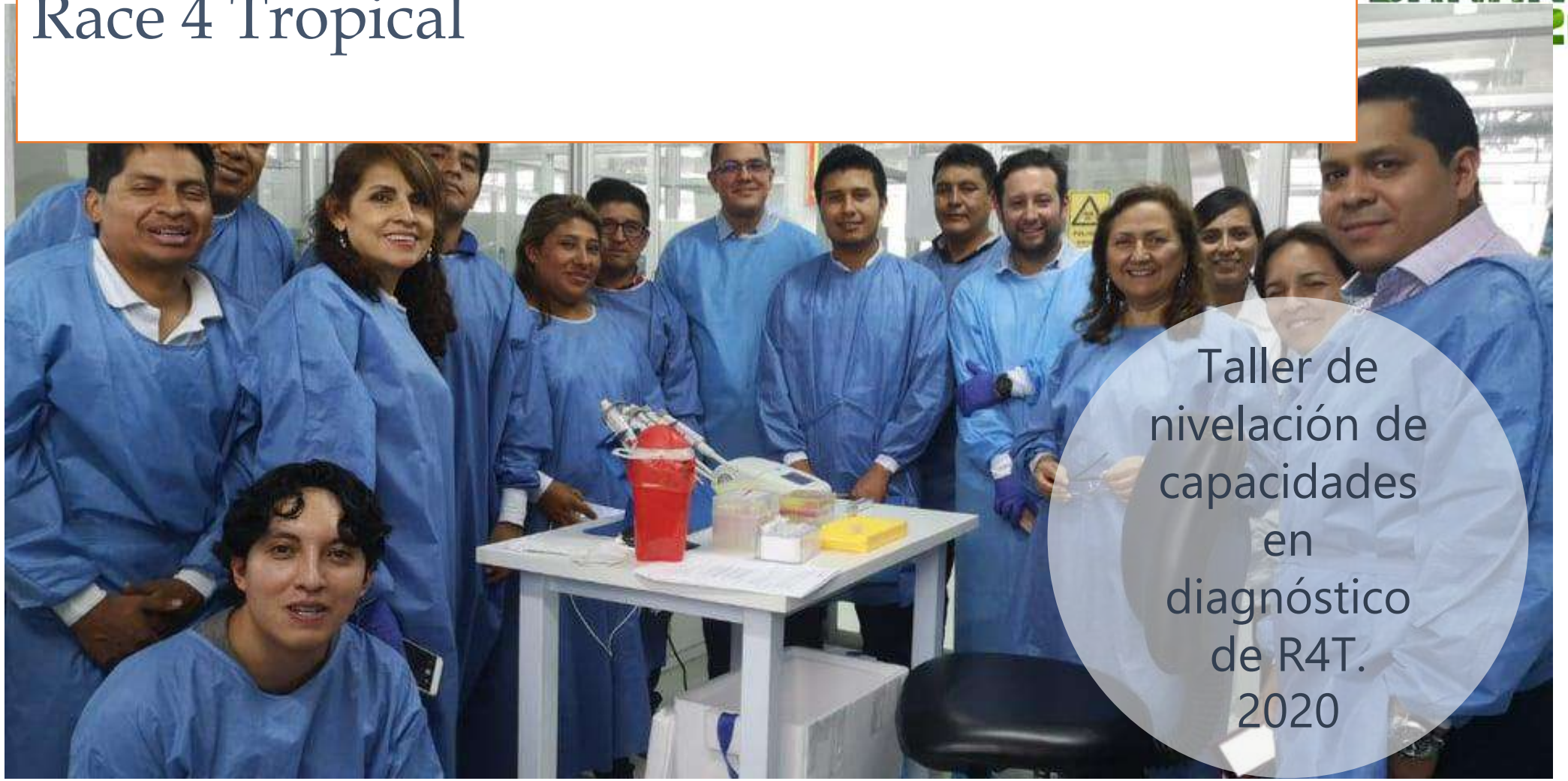
Communications Biology 2, Article number: 46 (2019) | Download Citation





ABBB meeting – Tanzania May, 2022

Andean Guide to the Diagnosis of Fusarium Race 4 Tropical



The Future Is Diversity

Agradecimientos

FORO BANANERO 2022

Banana Team at Keygene


Anker Sørensen


Fernando García


Rene Hofstede


Alex Bersgma

Greenhouse

Rolf Mank
Luuk Wilbers
Has van den Heuvel
Herbert Schrijver


Jeroen Berg


Reza Talebi


Orhan Oskan

Collaborators at KeyGene

Laboratory

Bipna Shrestha
Anna Finkers
Tanya Radoeva
Franck Lhuissier
Noor V rEekum
Lisanne Blommers
RSG group

Bioinfomatics

Dennis Woltinge
Marcel Van Verk
Alexander Wittenberg
Rui Peng Wang
Koen Nijbroek
Lian Perebolde
Marley Yeong
Anna Freudenreich
Koen Hovenaars
Marielle Sengers
Pauline van Haperen

yelloway
the banana breeders

Chiquita

MusaRadix

WAGENINGEN UR
For quality of life

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