Outbreaks: Tackling Emerging Plant Diseases that Threaten Food Security

January 10, 2020
1-7PM
Ocracoke Room, Talley Student Center

NC STATE UNIVERSITY Global Food Security

Sponsored by the Chancellor's Faculty Excellence Program at NC State University

Emerging Plant Disease and Global Food Security

THE CHALLENGE VIRUSES IMPOSE ON CASSAVA CROPS

TRINO ASCENCIO-IBÁÑEZ

MOLECULAR AND STRUCTURAL BIOCHEMISTRY

NORTH CAROLINA STATE UNIVERSITY

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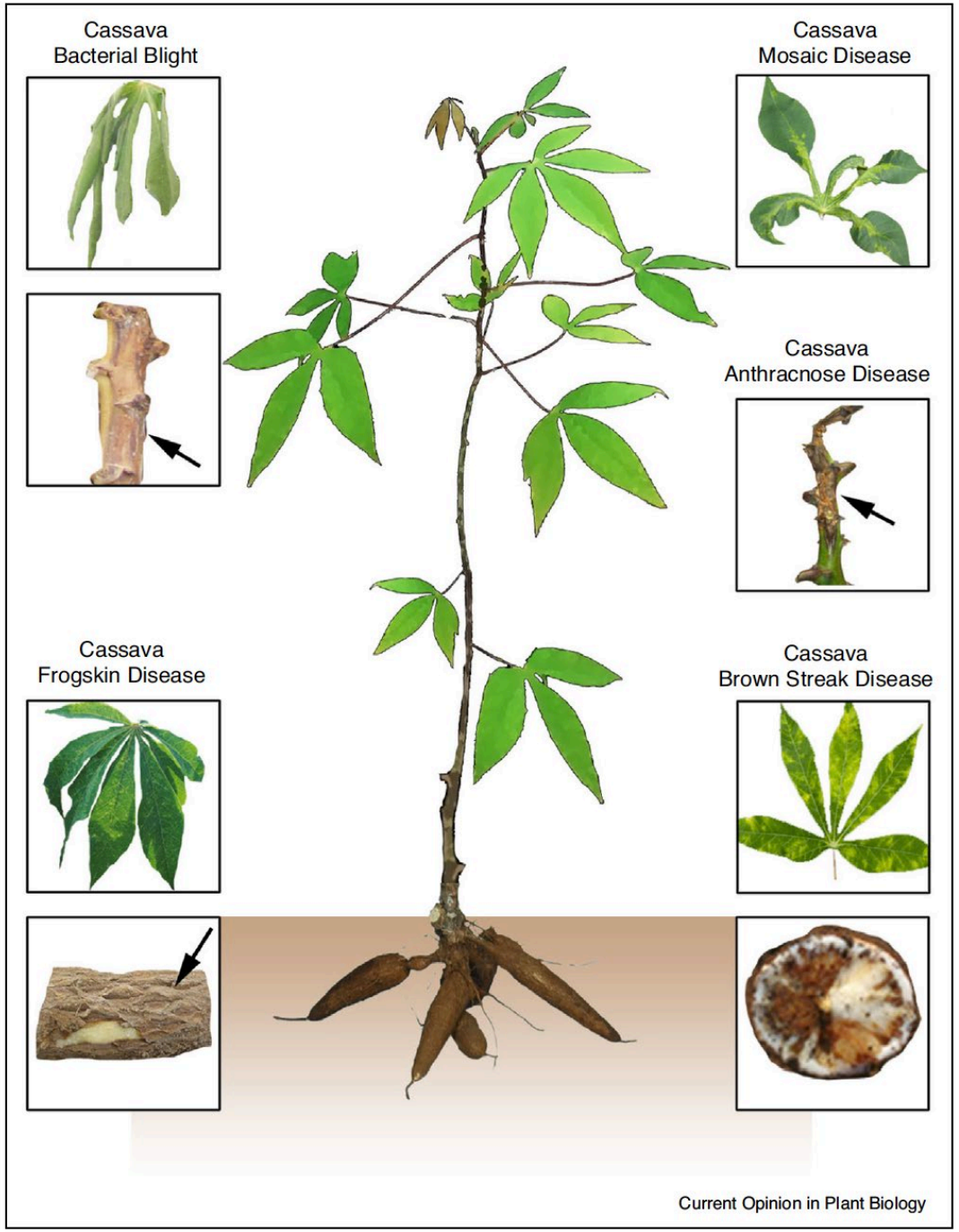
CASSAVA (YUCCA, MANDIOCA, TAPIOCA)

- PLANT FROM THE AMERICAS
- ORIGIN: BRAZIL
- DIVERSIFICATION IN BRAZIL AND MEXICO
- *Manihot esculenta* (*Euphorbiaceae*)
- Taken to Africa by the Portuguese centuries ago

STAPLE FOOD FOR MANY IN AFRICA, IT FEEDS 70 MILLION

MANY DISEASES ARE FOUND IN CASSAVA



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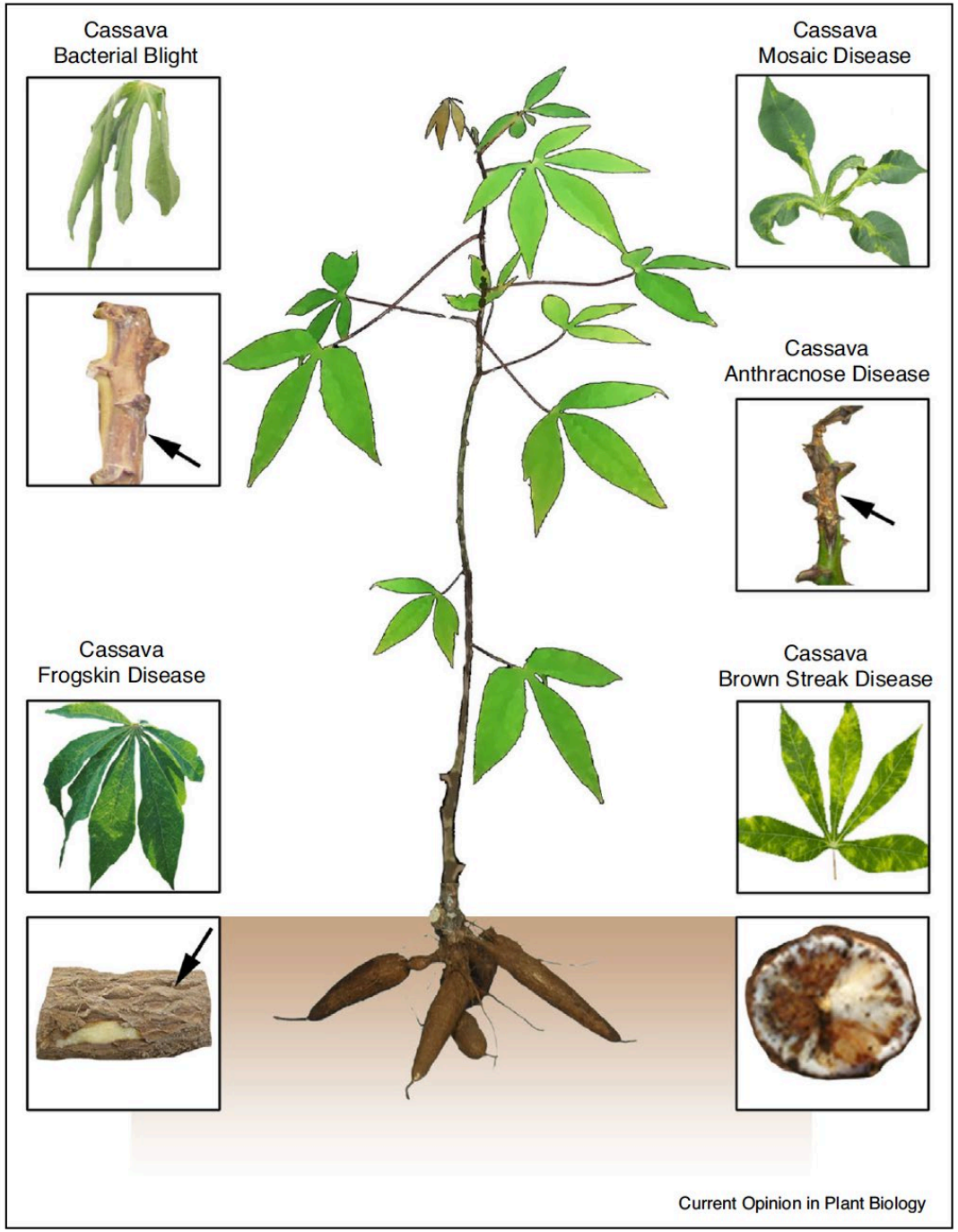


MAIN VIRUS COMPLEXES AFFECTING CASSAVA IN EAST AFRICA

Cassava Mosaic Disease

ACMV, EACMCV, EACMCV-Ke

CMD=10 species (8 in Africa)

Geminiviruses

Cassava Brown Streak Disease

UCBSV-Ke125

Mainly 2 species

Potyviruses

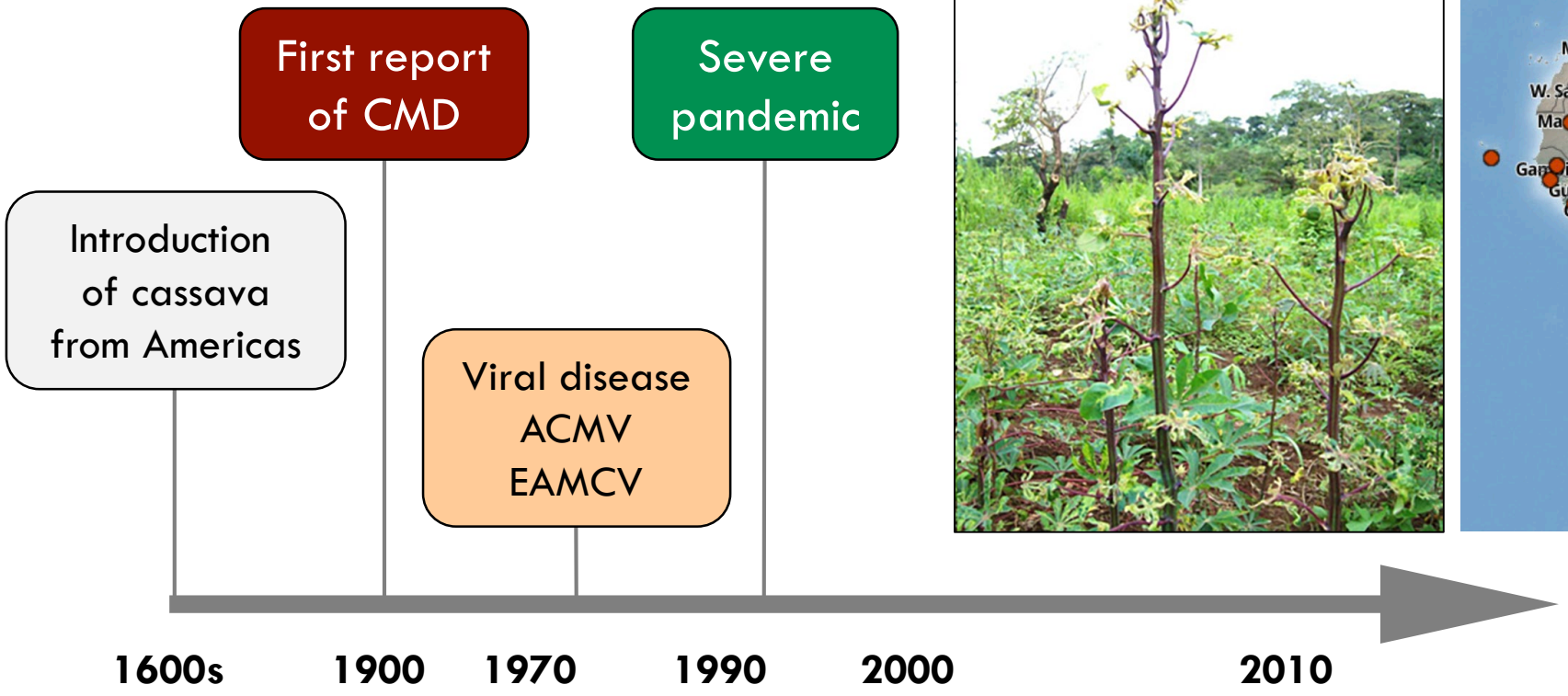
WHAT IS THE PROBLEM WITH THESE VIRUSES?

FURTHERMORE: CASSAVA IS TRADED AS PROPAGATIVE STOCKS

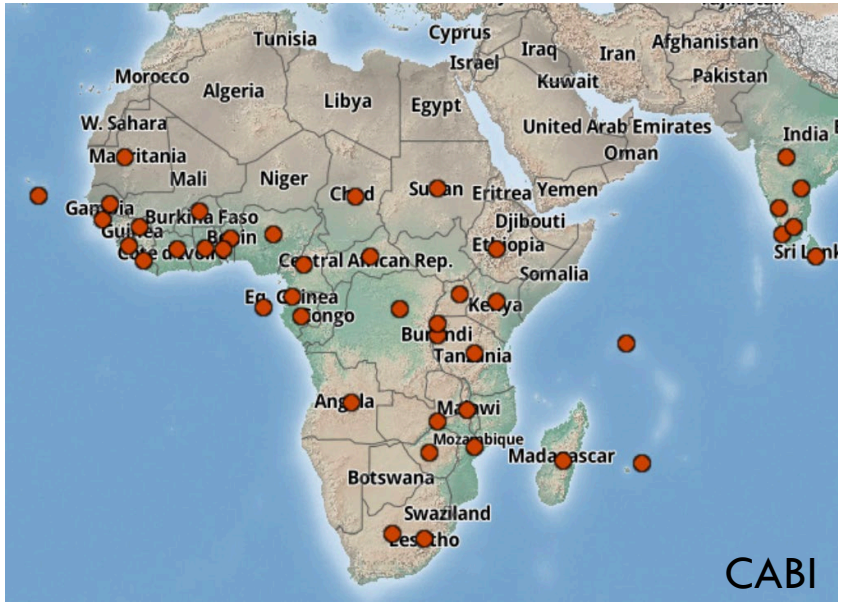
CMD DISEASE COMPLEX

- 10 begomovirus species (8 in Africa)
- 5.5-kb genome
- 2 genome components
- Whitefly transmitted
- 12-23 million tons loss/year (CABI estimations) before pandemic

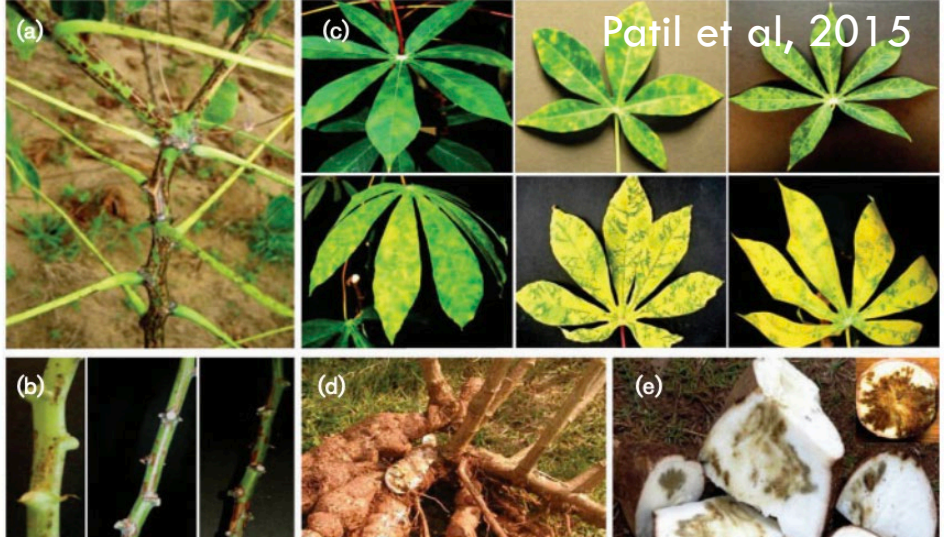
CMD THROUGH TIME



Lava Kumar IITA



Factors contributing to the pandemic: Recombinant virus, synergy and vector abundance



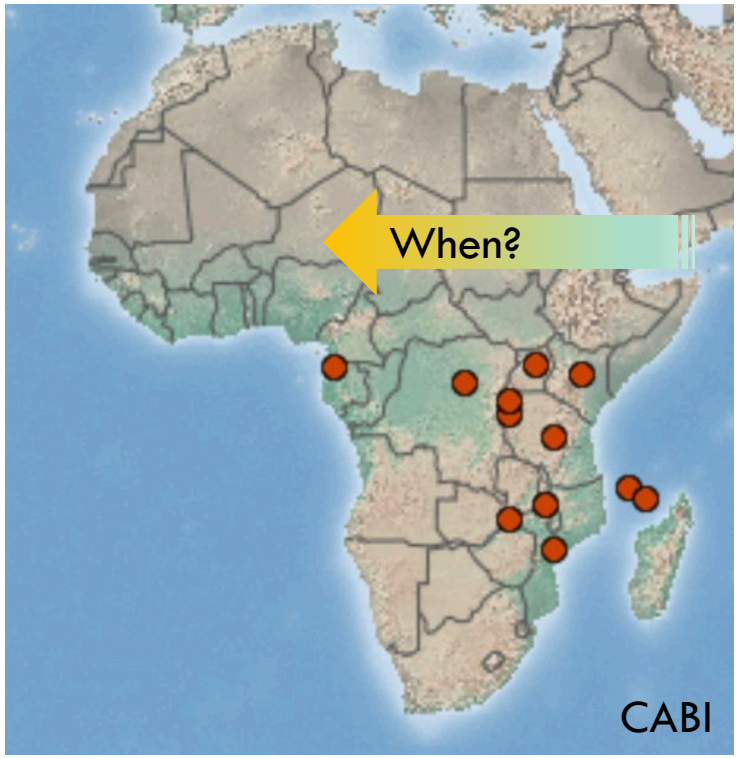
Patil et al, 2015

CBSV DISEASE COMPLEX

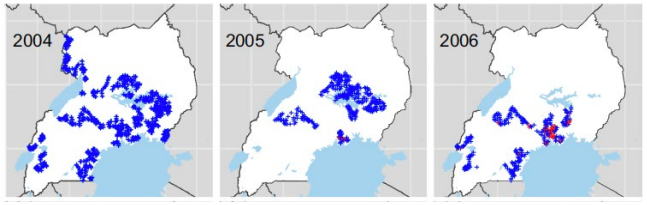
- 2 Ipomovirus species
- Cassava brown streak virus and Ugandan cassava brown streak virus
- Whitefly transmitted

Photo credit: Ndunguru

CBSD THROUGH TIME IN UGANDA



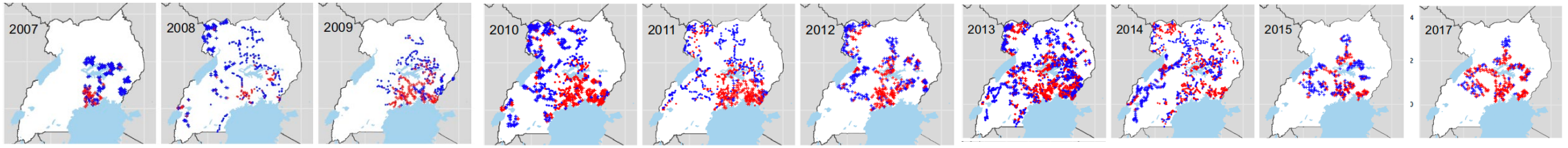
2004 to 2006



absent

present

2007 to 2017



Alicai et al, 2019

CMD AND CBSD ARE SYNERGISTIC

PLEASE VISIT POSTER #5 FOR MORE INFORMATION ON SYNERGISM

Photo credit: Ndunguru

CMD AND CBSD ARE THREATENING FOOD SECURITY IN EAST AND WEST SUB-SAHARIAN AFRICA

HOW CAN WE TACKLE THIS ISSUE?

2 MAIN GRANTS

1 PROPOSAL

NC STATE UNIVERSITY

NSF-PARTNERSHIP IN INTERNATIONAL RESEARCH AND EDUCATION (PIRE):

"US-EAST AFRICA RESEARCH AND EDUCATION PARTNERSHIP: CASSAVA MOSAIC DISEASE – A PARADIGM FOR THE EVOLUTION OF INSECT-TRANSMITTED PLANT VIRUS PATHOSYSTEMS"

NC STATE UNIVERSITY

NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

ECSU ELIZABETH CITY STATE UNIVERSITY FOUNDED 1891

RUTGERS School of Environmental and Biological Sciences

AUBURN UNIVERSITY

biosciences eastern and central africa

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY TECHNOLOGY FOR DEVELOPMENT

AGRICULTURAL RESEARCH INSTITUTE MARI MIKOCHENI

BILL & MELINDA GATES foundation

"CASSAVA MOSAIC DISEASE SUSCEPTIBILITY AND RESISTANCE: TRANSLATION FROM ARABIDOPSIS TO CASSAVA"

NC STATE UNIVERSITY

AGRICULTURAL RESEARCH INSTITUTE MARI MIKOCHENI

THE EVOLUTION OF THE CMD DISEASE COMPLEX IS FAST

- High mutation rate (10^{-3}-10^{-4})
- Recombination
- Reassortment

MANY FACTORS THAT COULD INFLUENCE VIRAL EVOLUTION

Vegetative vs. insect transmission

Single virus vs. mixed infection

Cassava cultivar

Reservoir plants

Environmental effects

Whitefly haplotype

Sequences Enhancing Geminivirus Symptoms (SEGS)

PLEASE VISIT POSTER #3 FOR MORE INFORMATION ON SEGS

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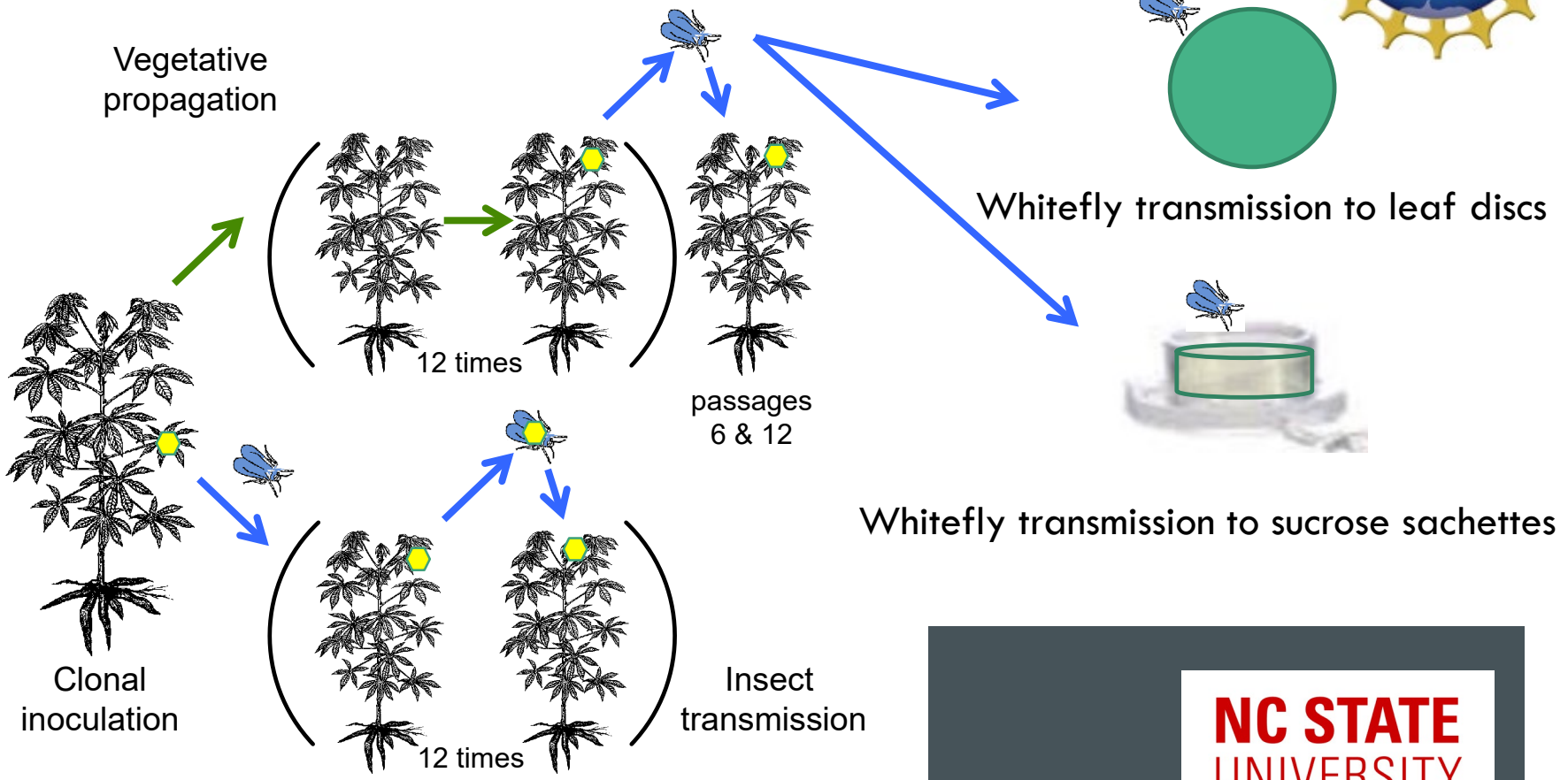
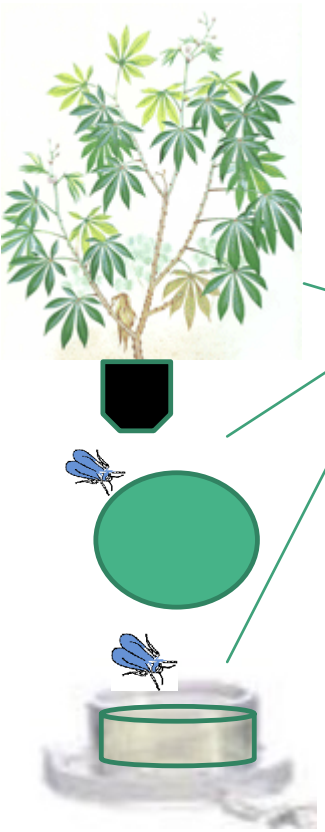
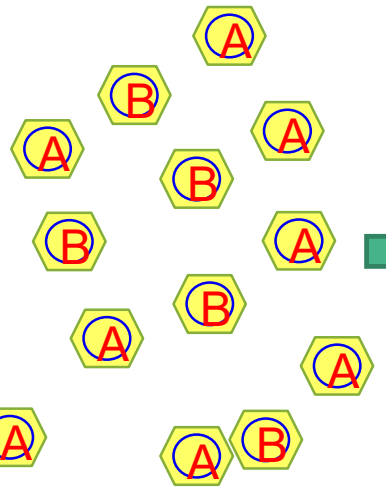
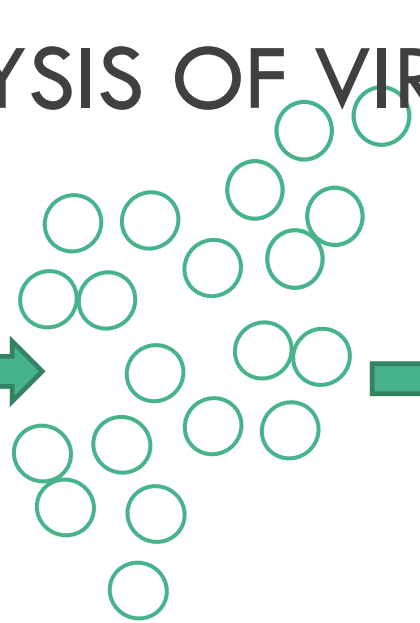
SERIAL ANALYSIS OF CASSAVA BEGOMOVIRUS EVOLUTION IN REAL TIME

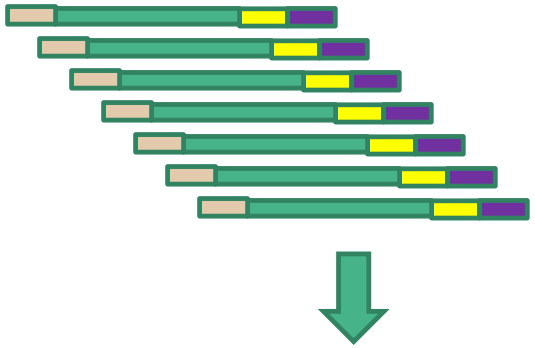


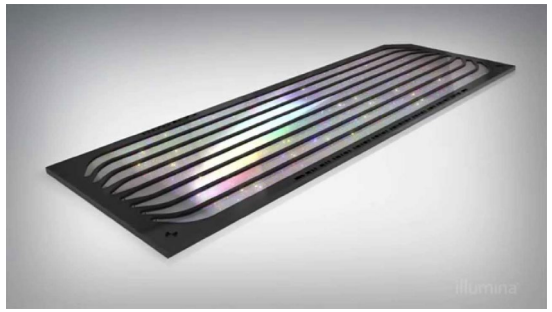
ANALYSIS OF VIRAL DIVERSITY

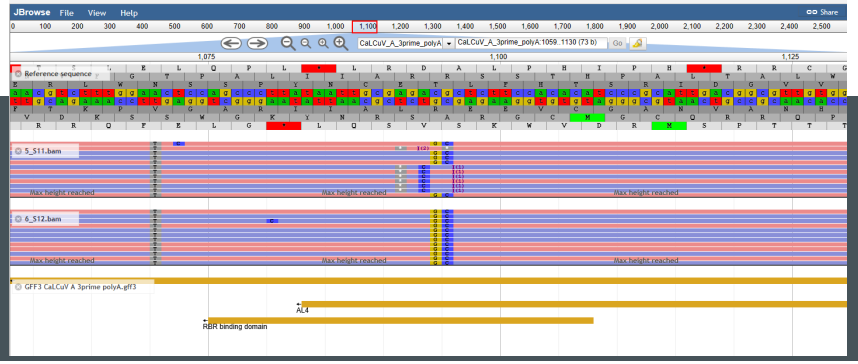












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RECENTLY, WE ADDED ONE POTYVIRUS CBSV INFECTIOUS CLONE TO OUR BATTERY OF GEMINIVIRUS INFECTIOUS CLONES

NOW WE CAN START STUDYING THE INTERACTION BETWEEN CBSD AND CMD IN CASSAVA

HOW CAN WE FIND RESISTANCE AGAINST VIRUSES?

THE SEARCH FOR A SOURCE OF RESISTANCE IN A HUMBLE PLANT

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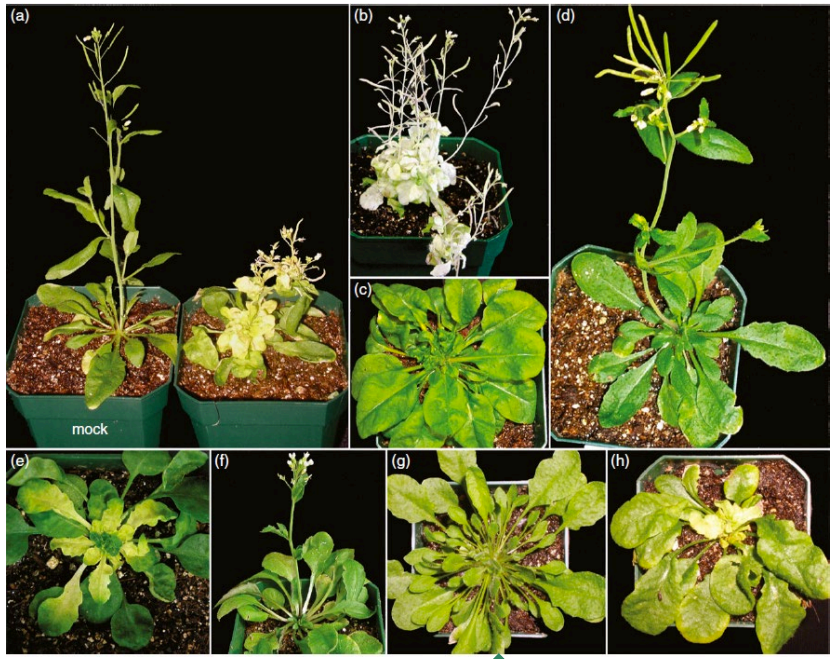
FINDING RESISTANCE AGAINST GEMINIVIRUSES



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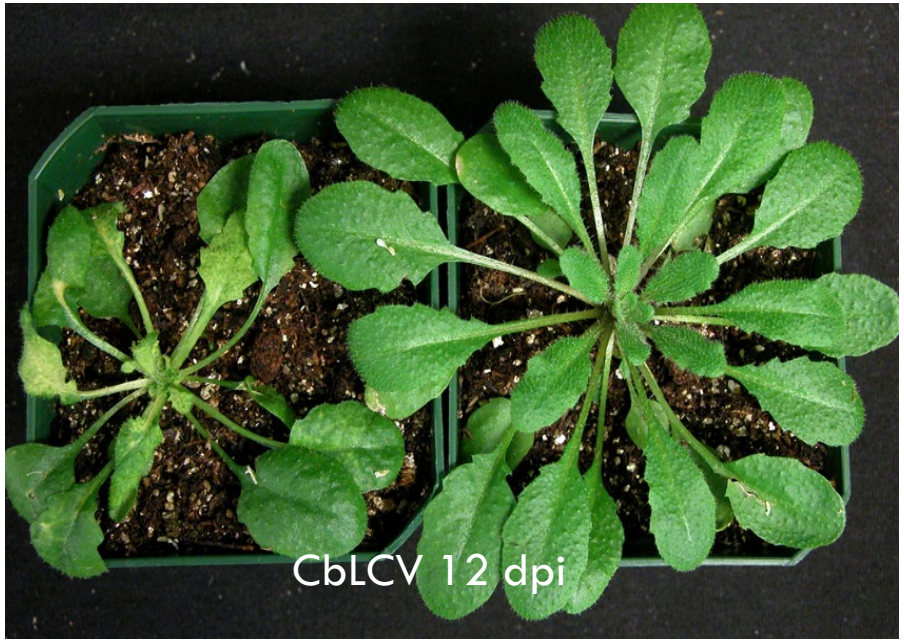
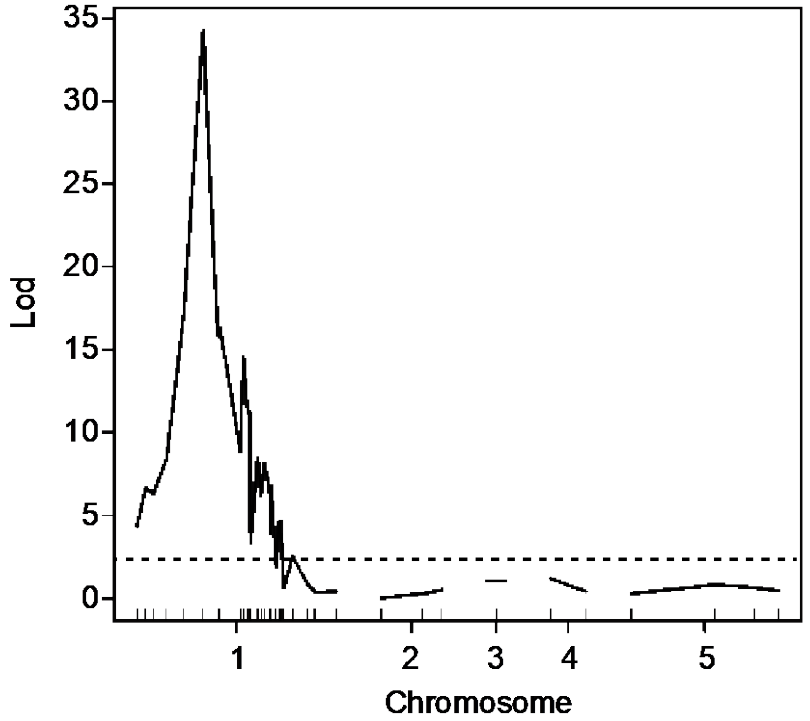
QTL mapping for CaLCuV Resistance in Arabidopsis Pla-1

- **The immunity is mapped to chromosome 1**

Col-0 Pla-1



Reyes et al. (2017) *Plant J.* **92:**796



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HOW ARE WE GOING TO TRANSLATE THIS TO CASSAVA?

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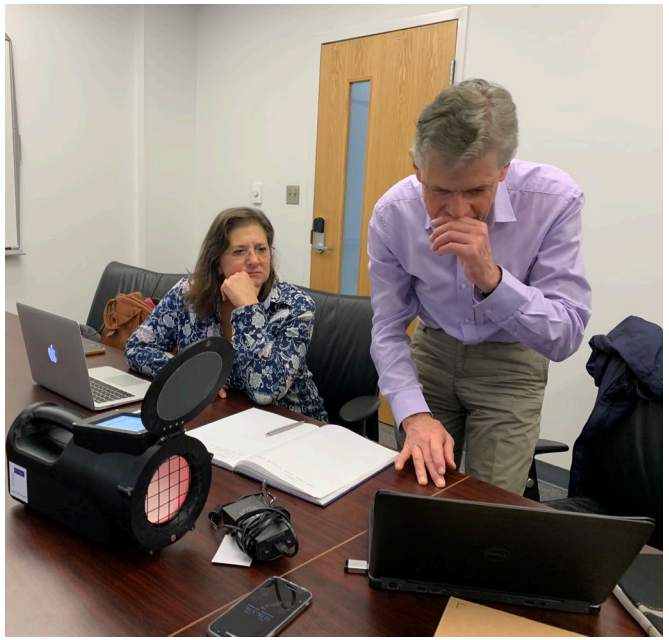
MULTIPRONG APPROACH TO PROTECT CASSAVA (PROPOSAL)

- Identify corresponding genes in cassava for resistance to CMD
- Edit genes in cassava to match protein sequence from *Arabidopsis*
- Edit SEGS1 out of the cassava genome
- Transform cassava with genes from *Arabidopsis*
- Use other available sources of resistance like peptide aptamers to enhance cassava resistance
- Transfer other known technologies to confer resistance to CBSV
- Provide cassava with resistance to whiteflies or with coat protein saturation to prevent transmission
- Find a hyperspectral signature that provides a faster way to identify resistance in cassava against viruses (any) and other pathogens
- Use hyperspectral early detection systems to eliminate possible sources of infection before symptom appearance to support the production of virus free plant material



COLLABORATION WITH THE UNIVERSITY OF MANCHESTER

INITIAL TESTS IN DECEMBER 2019

PIRE SENIOR PERSONNEL

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George Kennedy

Ignazio Carbone

Trino Ascencio-Ibanez

Siobain Duffy

Alana Jacobson

Louis Jackai

Tim Goodale

BecA-ILRI Hub

Jacob Mignouna

Josiah Mutuku

Wellington Ekaya

MARI

Joseph Ndunguru

Peter Sseruwagi

ACKNOWLEDGMENTS

PLEASE VISIT POSTER #3 AND POSTER #5 FOR FURTHER INFORMATION IN SOME OF THE TOPICS PRESENTED HERE

PIRE TRAINEES AND TECHNICAL STAFF

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Yamilex Rosado (undergraduate)
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Mary Wambugu (senior technician)
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NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

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- Dr. Wei Shen (Senior Scientist)
- Dr. Cyprian Rajabu (former postdoc)
- MSc. Evangelista Chiunga (PhD student)
- MSc. Kayla Beam (MSc. student)
- Dr. Bruce Grieve

QUESTIONS?

SOME OF OUR WONDERFUL TRAINEES, COLLABORATORS AND STAKEHOLDERS IN KENYA AND TANZANIA