Possible Impacts of the Whitefly Q Biotype on Viral Diseases in Tomato

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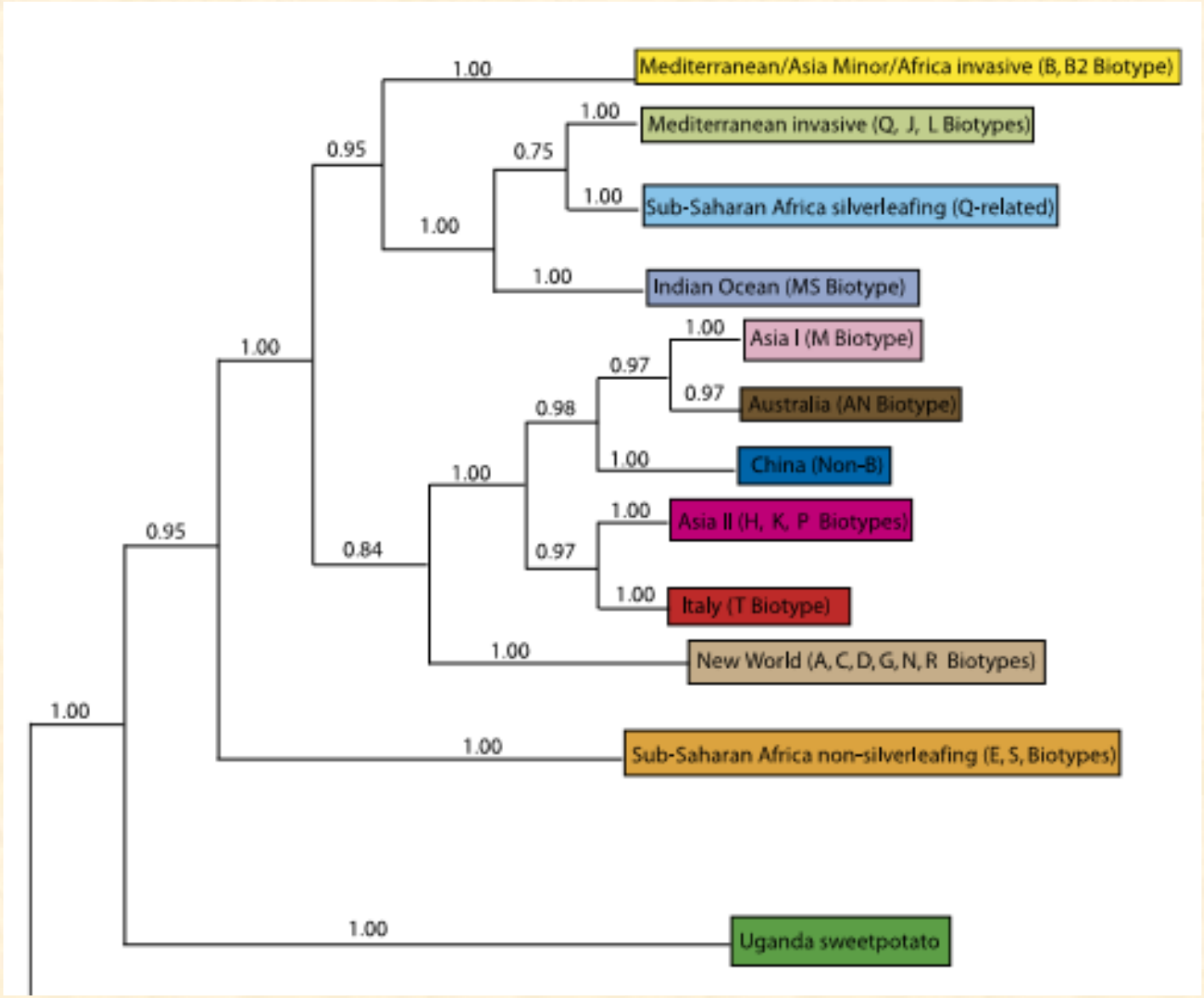
The Whitefly, *Bemisia tabaci,* is a complex of 12 clades (soon to be 12 separate species)



"B" biotype

"Q" biotype

Whiteflies look identical: Can only be identified by molecular tools

"A" biotype

L.M. Boykin et al. / Molecular Phylogenetics and Evolution 44 (2007) 1306–1319

Detection of Biotype Q: 2011 – 2016

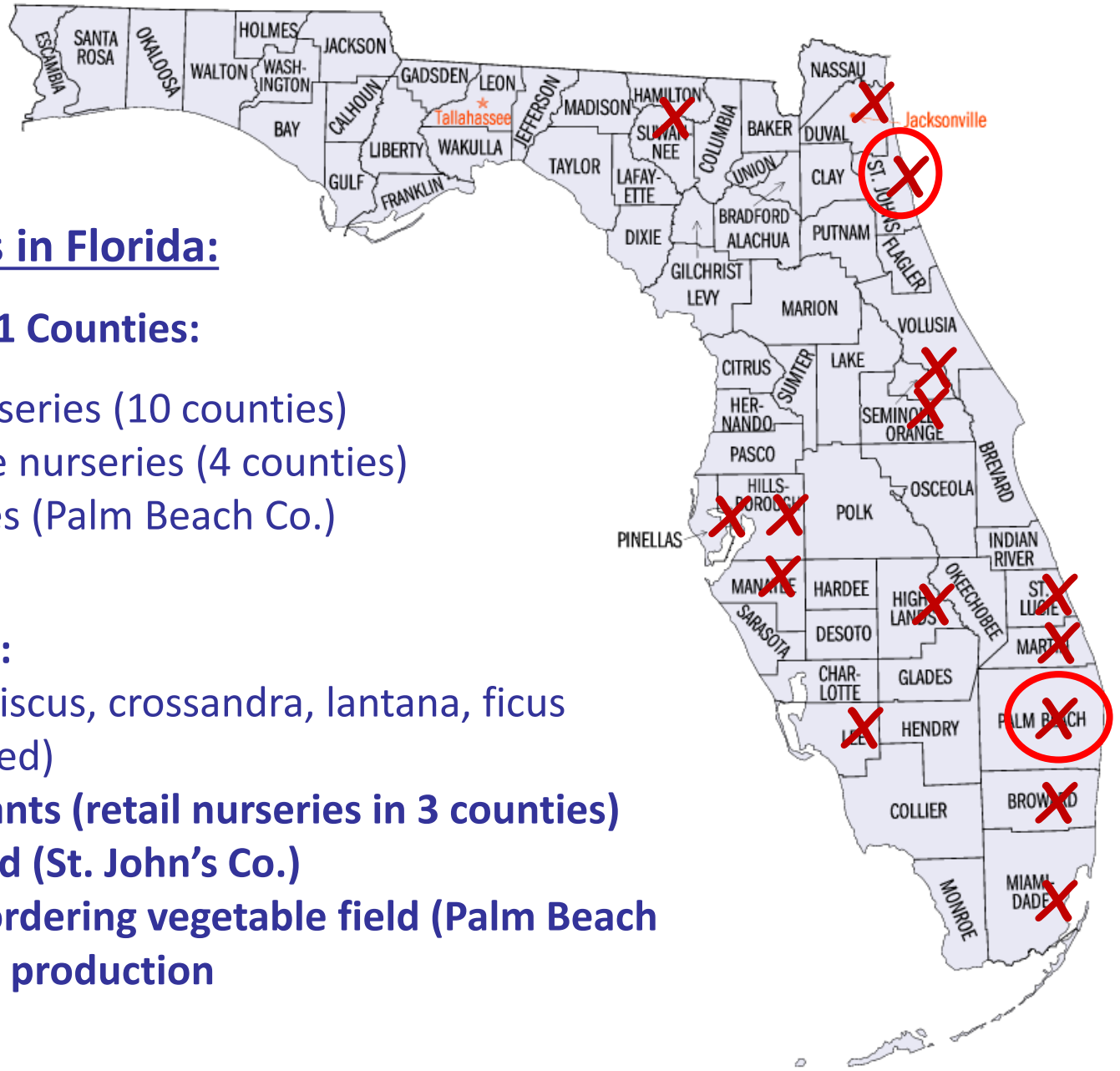
Year	Q Whiteflies/Total Whiteflies Tested	Type of Host Plant	Location of Collected Whiteflies
2011	8/68	Ornamentals	Georgia, **Florida**
2012	7/96	Ornamentals	New Hampshire, Quebec, Canada
2013	4/45	Ornamentals	**Florida**, Oregon, San Paulo Brazil
2014	42/79	Ornamentals	Oregon, New York, New Jersey, **Florida**, BC Canada, Quebec Canada
2015	5/62	Ornamentals	Oregon, Vermont
2016	51/219	Ornamentals Eggplant Weeds	Ontario Canada, **Florida** (45), California

Modified from: C. McKenzie, USDA-ARS

2016 Q Detections in Florida:

45 Q Whiteflies in 11 Counties:

- 16 from Retail Nurseries (10 counties)
- 8 from wholesale nurseries (4 counties)
- 10 from residences (Palm Beach Co.)



Host Plants Involved:

- Ornamentals (hibiscus, crossandra, lantana, ficus hedge, porter weed)
- **Eggplant transplants (retail nurseries in 3 counties)**
- **Sweet Potato field (St. John's Co.)**
- **Morning glory bordering vegetable field (Palm Beach Co.) prepared for production**

Modified from: C. McKenzie, USDA-ARS

What does this mean for virus epidemics in Florida tomatoes?

- Q biotype is unlikely to be contained and will continue to spread
- Q biotype likes to feed and reproduce on tomatoes
- There are biological differences between the B and Q biotypes that affect their role as vectors:
  - May feed differently on the same hosts
  - Have overlapping but different host ranges
  - Q biotype is highly resistant to insecticides
  - Q biotype outcompetes B biotype under conditions of pesticide applications (most tomato fields)
- So it is very likely that Q that is going to be the more common whitefly in Florida tomato fields, and is going to be more challenging to manage populations of Q whiteflies in tomato fields

The biological differences between the B and Q whiteflies may result in the following in one or more crops in Florida:

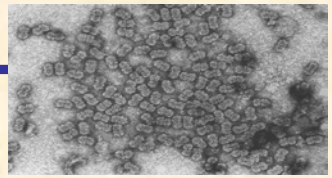
1. Appearance of new viruses
2. Disappearance of established viruses
3. Changes in frequency of plants infected with any whitefly-transmitted virus
4. Appearance of new diseases (virus known in a crop is found in another crop for the first time)

These changes in viral pathogens can also result in regulatory responses by other states and countries that want to exclude those viruses.

Plant Viruses Transmitted by *Bemisia tabaci* species complex

Family	Genus	Type of Transmission
Geminiviridae	*Begomovirus*	Persistent, circulative
Closteroviridae	*Crinivirus*	Semi-persistent
Potyviridae	*Ipomovirus*	Semi-persistent
Betaflexiviridae	*Carlavirus*	Non-persistent
Sequiviridae	*Torradovirus*	?

Begomoviruses In Florida



Before B Biotype

Viruses in *Sida* spp.

Sida golden mosaic virus (1993)
Sida golden mosaic Florida virus (1995)
Sida golden mottle virus (2004)
Sida golden yellow vein virus (2012)
Sida golden mosaic Yucatan virus (2011)

Macroptilium yellow mosaic Florida virus (2003)
Uncharacterized virus in *Rhynchosia minima*
Euphorbia mosaic virus (2011)
Jatropha mosaic virus (1980/2011)
Abutilon mosaic virus (decades, maybe longer)
Chenopodium leaf curl virus (2000/2010)

After B Biotype

Tomato mottle virus (1989)
Bean golden yellow mosaic virus (1993)
Cabbage leaf curl virus (1995)
Dicliptera yellow mottle virus (???, 1996)
Tomato yellow leaf curl virus (1997)
Cucurbit leaf crumple virus (2007)

KEY:
Indigenous
Introduced

Other Bemisia –Transmitted Viruses In Florida

- ***Closteroviridae, Crinivirus –***
  Tomato chlorosis virus (early 1990's??)
  Cucurbit yellow stunting disorder virus (2007)

- ***Potyviridae, Ipomovirus –***
  Squash vein yellowing virus (early 1990's)

- ***Betaflexiviridae, Carlavirus –***
  Cowpea mild mottle virus (??)

- ***Sequiviridae, Torradovirus***
  (not reported from Florida yet)

Some Factors that Vary Among Different Whiteflies that Affect Transmission of Plant Viruses

- **Hosts of the whitefly**
  - If Q feeds on different hosts than B, then it may pick up different viruses or create mixed infections of different viruses that the B did; it may also change which plants serve as virus reservoirs
- **Feeding behavior of the whitefly on each host**
  - If the host is less preferred, then only probing may occur, or feeding times may be shorter
  - The longer a whitefly feeds the more likely it is to acquire or transmit a virus
- **Resistance to pesticides**
  - The population size of the vector as well as seasonal variations affects how many plants will become infected

If these factors vary among biotypes, then you would expect changes in ability to transmit, or in efficiency of transmission, and in the occurrence and frequency of the transmitted viruses

What we know about how well B and Q transmit the same virus:

Virus Genus	Virus Species	Trans. by B	Trans. by Q	Difference in Trans. Rates
Begomovirus	*Bean golden yellow mosaic virus*	yes	?	?
	Tomato mottle virus	yes	?	?
	Tomato leaf curl Taiwan virus	yes	yes	B better than Q
	Tomato yellow leaf curl virus	yes	yes	Similar; Q better than B
	Tomato yellow leaf curl Sardinia virus	yes	yes	Depends on host plant
	Tomato yellow leaf curl Thailand virus	yes	yes	B better than Q

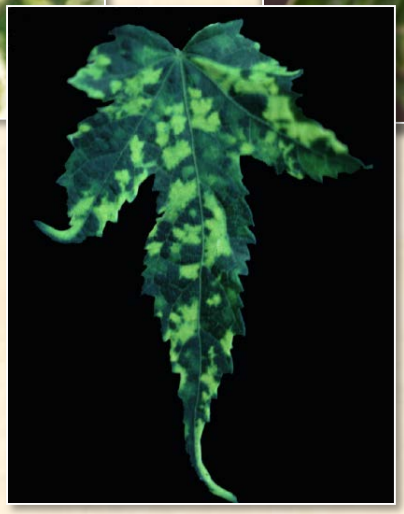
- Results also vary due to differences in how each experiment was conducted, as well as the use of different whitefly colonies, hosts and virus isolates

What we know about how well B and Q transmit the same virus:

Virus Genus	Virus Species	Trans. by B	Trans. by Q	Difference in Trans. Rates
Carlavirus	*Cowpea mild mottle virus*	yes	?	?
	Melon yellowing-associated virus	yes	?	?
Crinivirus	*Cucurbit chlorotic yellows virus*	yes	yes	?
	Cucurbit yellow stunting disorder virus	yes	yes	similar
	Tomato chlorosis virus	yes	yes	?
Ipomovirus	*Squash vein yellowing virus*	yes	?	?
	Cucumber vein yellowing virus	yes	?	?
Torradovirus	*Tomato necrotic dwarf virus*	yes	?	?
	Tomato torrado virus	?	?	?

- We lack a systematic understanding of how the biological differences between B and Q effect virus transmission

Studies with Begomoviruses



Begomoviruses: B vs Q

If a whitefly can feed on the infected plant then it is likely to be able to acquire and transmit that virus….

Region	Americas								Colony Africa			Middle East				Asia	
Virus	FN	CC	ArP	ArPu	GC	MNC	ANW	ABA	NI	SC	SAP	IsC	CyC	TC	YC	YW	PC	IW
CLCV[1]	+	+	+	+	+	+	+	–	–	+	+	+	+	+	+	+	+	+
SLCV[1]	+	+	+	+	+	+	+	–	–	+	+	+	+	+	+	+	+	+
BCMoV[1]	+	+	+	+	+	+	+	•	–	+	+	+	+	+	+	+	+	+
SGMV-H[1]	+	+	+	+	+	+	+	–	•	+	+	+	+	+	+	+	+	+
SGMV-CR[1]	+	+	+	+	+	+	+	•	–	+	+	+	+	+	+	+	+	+
TYLCV-Y[2]	+	+	+	+	+	+	+	–	+	+	+	+	+	+	+	+	+	+
TLCV-Y[2]	+	+	+	+	+	+	+	–	–	+	+	+	+	+	+	+	+	+
WCSV[2]	+	+	+	+	+	+	+	–	–	+	+	+	+	+	+	+	+	+
PYVV[2]	–	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–	–
ACMV-N[3]	+	+	+	+	•	+	+	–	•	•	+	+	+	•	•	•	•	–
BLV[3]	+	+	+	+	+	+	+	•	•	•	+	+	+	+	+	+	+	+
SYVV[3]	+	+	+	+	+	+	+	•	•	+	+	+	+	+	+	+	+	+
AGMV[3]	+	+	+	+	+	+	+	+	–	+	+	+	+	–	–	–	+	+
HYVMV[4(5)]	–	–	–	–	–	–	–	–	•	–	–	–	–	–	–	–	–	–
AbMV[4(1)]	–	–	–	•	•	•	–	•	•	•	•	•	–	–	•	–	•	•
Biotype	B	B	B	A	G	D	B	E	J	L	B	B	B	M	B_2	B_2	K	H

+ = successful transmission, – = negative transmission, • = no data.
Virus originating from: [1]—the Americas, [2]—the Middle East, [3]—Africa, [4]—Europe, [5]—Far East.

However, begomovirus transmission efficiency can vary depending upon the whitefly, host, and virus

Bedford, et al 1994. *Ann. Appl. Biol.* 125:311-325

Example 2 - Differences in transmission efficiencies of TYLCV and TYLCSV by B and Q

Whitefly	Avg. Percent Transmission	
	TYLCSV	TYLCV
MEAM1	11.8c	33.7b
MED	40.1ab	50.0a

TYLCV displaced TYLCSV in tomato in Spain 1996-1998:

1. B and Q transmitted TYLCV more efficiently than TYLCSV
2. Q transmitted both viruses at higher rates than B
3. TYLCV had a local crop (bean) as an alternate host

Sanchez-Campos et al Phytopathology 89:1038-1043

China:

- TYLCV was introduced into China in 2006, approximately 10 years after the introduction of B biotype.
- TYLCV distribution and prevalence remained limited and economic damage was minimal,
- Q biotype was introduced in 2003, after which the prevalence and spread of TYLCV accelerated.

Pan et al (2012) PLoS ONE 7(4): e34817. doi:10.1371/journal.pone.0034817

Brazil:

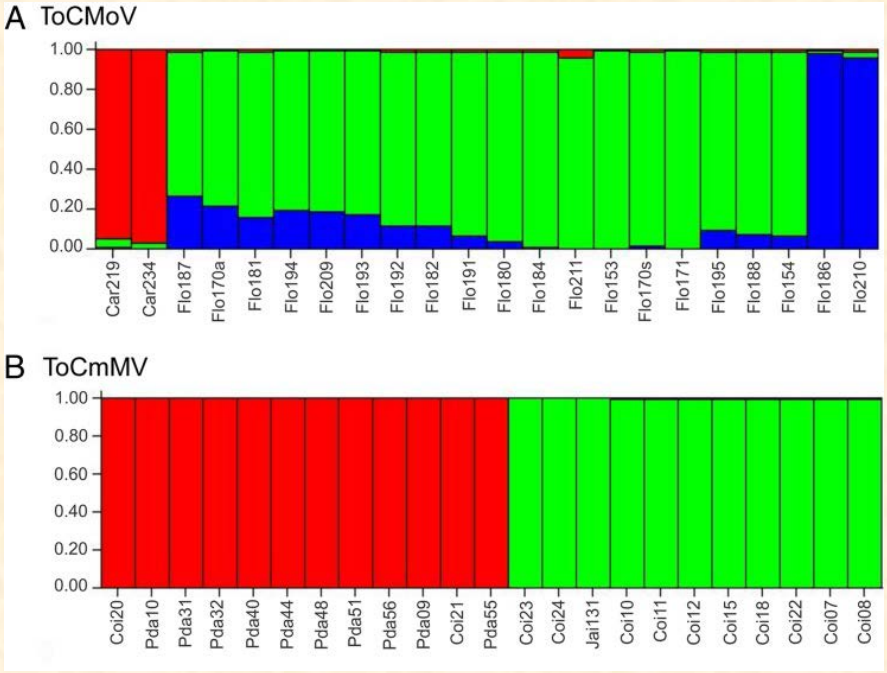
- *Tomato golden mosaic virus* (TMGV) disappeared in tomato in Brazil – 1980's
- B biotype arrived in the mid 1990's and approx. 10 new begomoviruses were reported in tomato – none of them TGMV

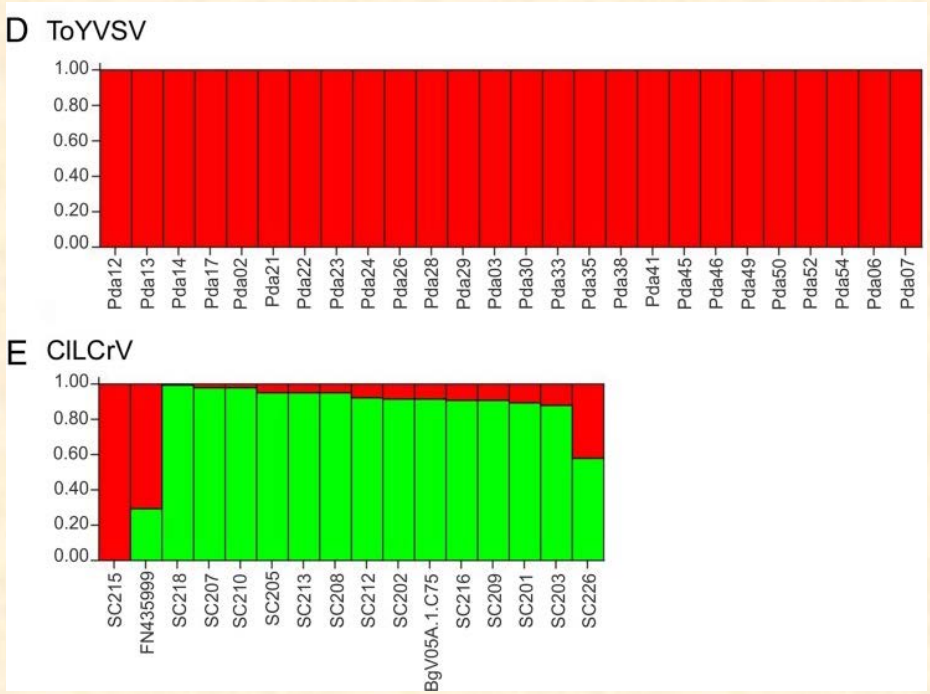
Rocha et al 2013 J. of Virology 87: 5784–5799

In mixed infections, begomoviruses exchange their DNA (recombine) to form new strains and new viruses

Recombination in Brazilian Begomoviruses:

Sequences of 126 begomovirus isolates from tomato and weeds were analyzed and arranged to illustrate the extensive recombination that was found





Same color indicates same viral origin

Rocha et al 2013 J. of Virology 87: 5784–5799

Studies with Criniviruses

Differences in transmission efficiency can cause viruses to disappear

Example: Introduction of B biotype to CA caused a big decrease in the frequency of plants infected with *Lettuce infectious yellows virus* (LIYV)

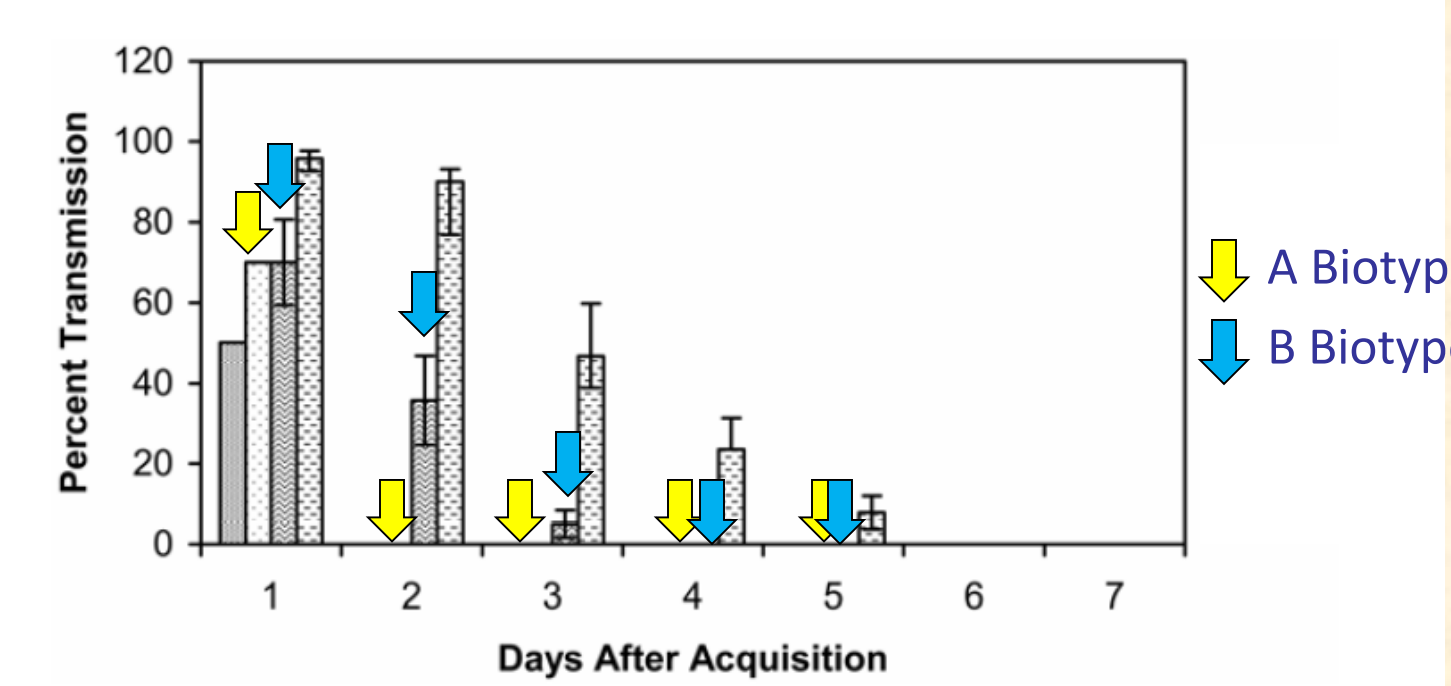
B transmitted LIYV less efficiently than A, so when B displaced A, LIYV essentially disappeared

Cohen et al 1992 Phytopathology 82:86-90; Duffus 1995 pp 12-16 in: Cucurbitaceae ’94

How long a virus is retained can vary among biotypes

Example: Persistence of *Tomato chlorosis virus* in A and B

- Biotype B transmitted *Tomato chlorosis virus* more efficiently than A



- Biotype B transmitted *Tomato chlorosis virus* for a longer period than A

Wintermantel and Wisler. 2006.Plant Dis. 90:814-819

Other Considerations:

- Whiteflies can feed differently on healthy and virus-infected plants which may change the efficiency of virus acquisition and transmission
- Endosymbionts have been shown to play a role in transmission, and the species of endosymbionts can vary among populations of the same whitefly
- While single crinivirus infections may remain asymptomatic but in mixed infections, criniviruses often interact with other viruses in plants and alter symptoms. They influence the accumulation of the other viruses present in the plant and thereby alter symptom severity.

Summary

- Biotype Q is likely to become more frequent in tomato fields over the next few years
- Q is likely to outcompete B in tomato fields (based on experiences in other locations)
- After this occurs we are likely to see established viruses at higher frequencies, we may see different viruses, and some may disappear.
- These changes in viral pathogens may result in regulatory responses by other states and countries that want to exclude those viruses.