Tomato brown rugose fruit virus

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Background –Plant Viruses

- Sub-microscopic infectious agents
- Simple and diverse structure
  - DNA or RNA genome
  - Protein coat
  - Most plant viruses have ssRNA genomes
- A large number and diversity of viruses infect tomato
- Disease symptoms do not allow virus identification
- IPM is the best management approach

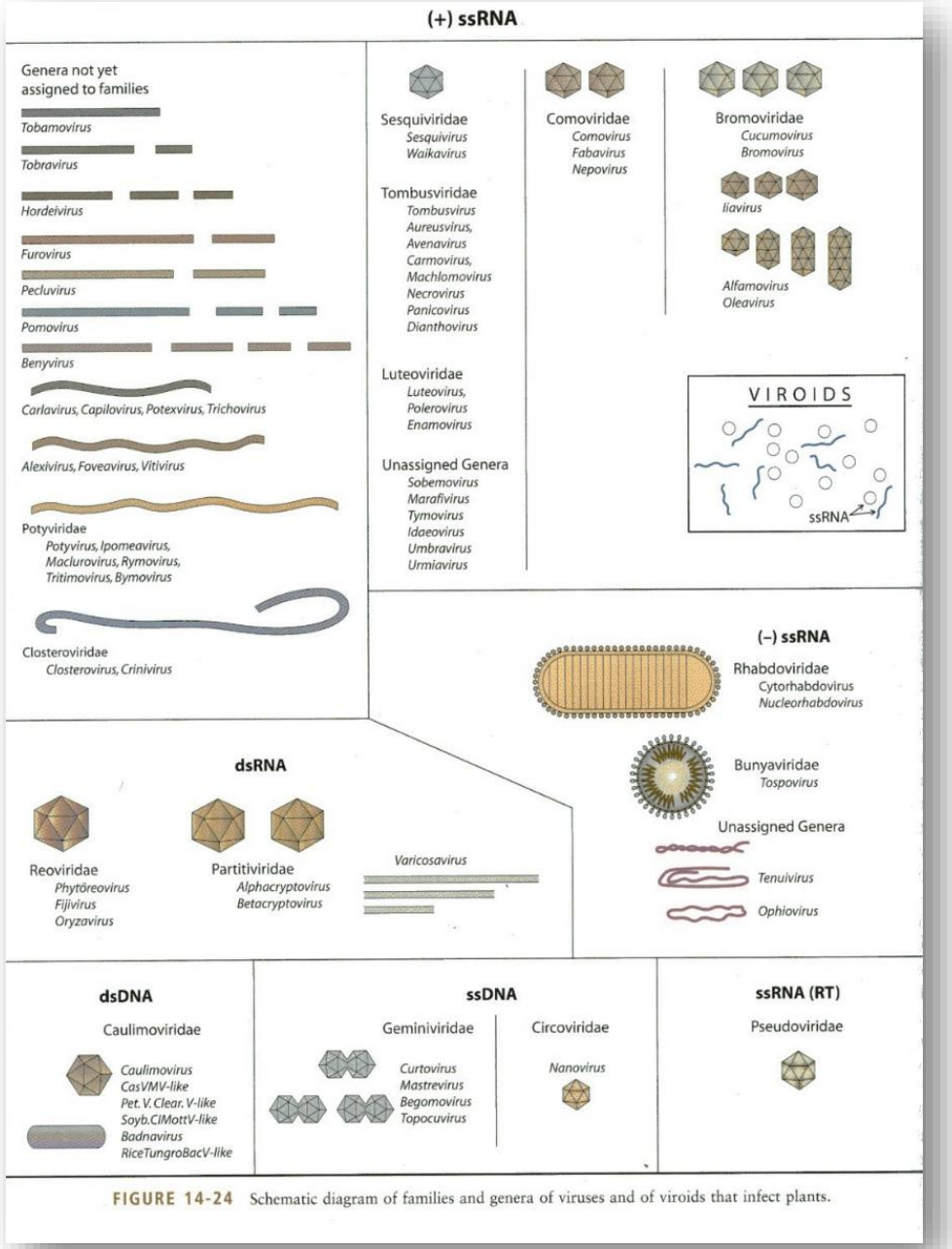

FIGURE 14-24 Schematic diagram of families and genera of viruses and of viroids that infect plants.

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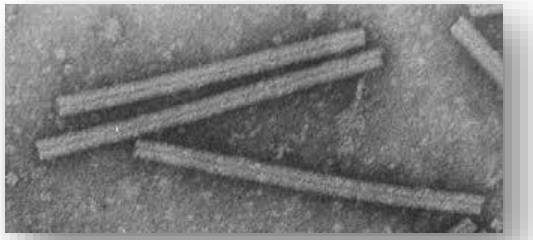
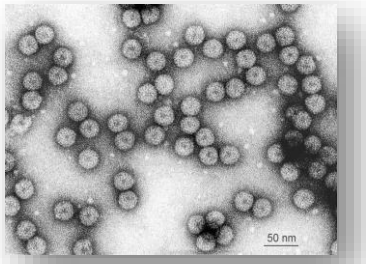
Different viruses can cause very similar symptoms

Tobacco mosaic virus **symptoms**

Cucumber mosaic virus **symptoms**

ToBRFV





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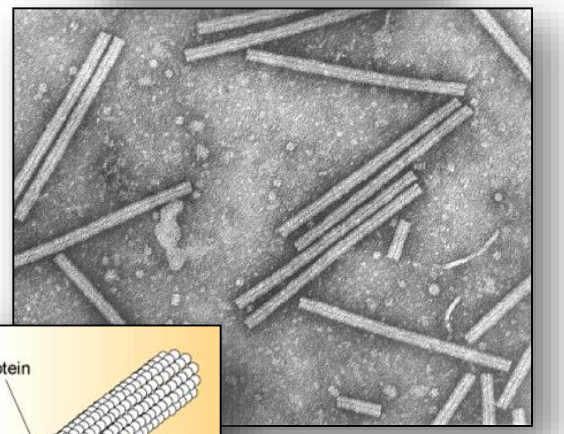
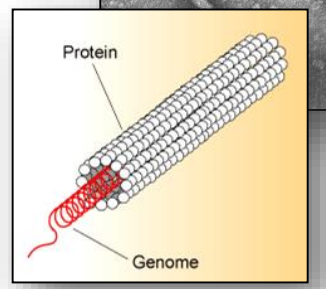
What is a *tobamovirus*?





- Well-known group of plant viruses: tobamoviruses
- Genus name derived from type species: *Tobacco mosaic virus* (TMV)
- There are 37 recognized species
- All tobamoviruses possess rigid rod-shaped virions and an RNA genome
- Virions are extremely stable (>20 years in dried leaf)
- Seed transmitted
- No insect vector -transmitted by contact and touch facilitated by activities of humans
- TMV is one of the most extensively studied viruses

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Multiple tobamoviruses infect tomato

At least five tobamoviruses infect tomato and induce similar symptoms:

- **Tobacco mosaic (TMV)**
- **Tomato mosaic virus (ToMV)**
- **Tobacco mild green mosaic virus (TMGMV)**
- **Tomato mottle mosaic virus (ToMMV)**
- **Tomato brown rugose fruit virus (ToBRFV)**

ToBRFV is associated with tobamovirus symptoms on resistant tomato varieties grown in protected culture

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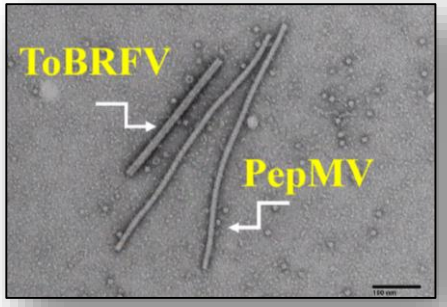
Tomato brown rugose fruit virus (ToBRFV)

- Virus can overcome TMV resistance genes in tomato
- Spreads rapidly within the crop
- Infected plants cannot be cured
- Prophylactic hygiene measures minimize spread and impact
- Infects pepper and other plants (petunia, tobacco, etc.)
- Usually found in mixed infection with *Pepino mosaic virus*.

Photos: Fidan et al. 2019



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ToBRFV is an emerging disease

Middle East

- First outbreak occurred in Israel in 2014; now present in all tomato growing regions
- In Jordan in 2015
- In Turkey in 2019

Americas

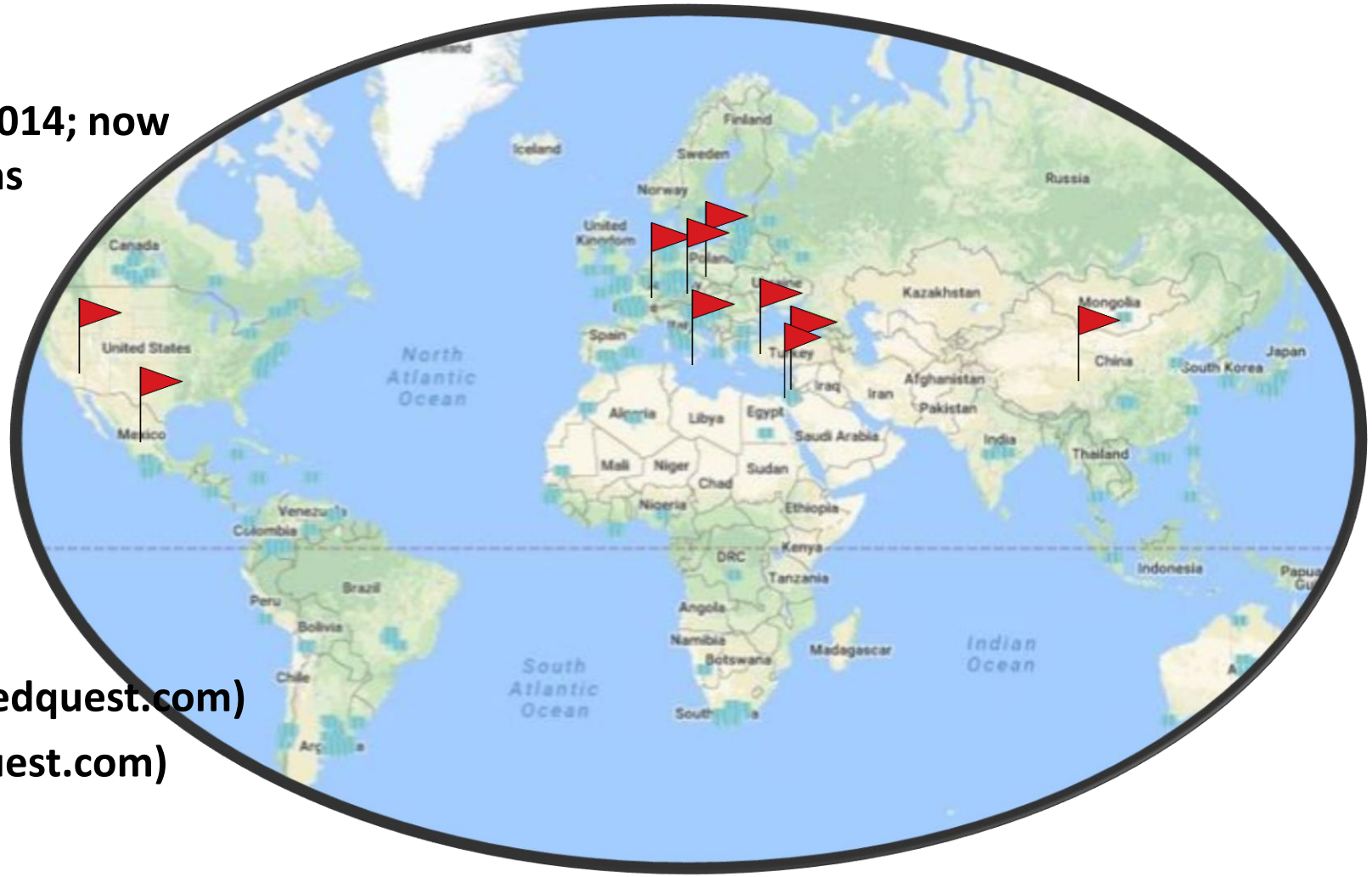
- Mexico and California, USA in 2018

Europe

- In Italy in 2018
- In Germany in 2018
- In Netherlands? in 2019 (Source: Seedquest.com)
- In Belgium? in 2019 (Source: Seedquest.com)

Asia

- In China in 2019



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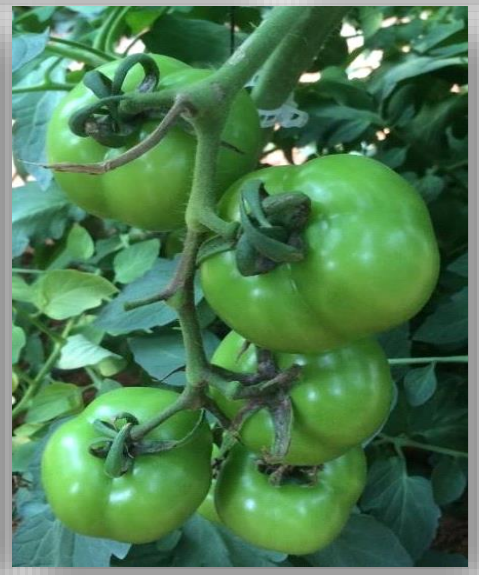
ToBRFV symptoms on tomato










Photos: Luria et al., 2017

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What is different about ToBRFV?

Photos: A. Dombrovsky and N. Salem

- Breaks Tm-2^2 resistance gene in tomato
- More rapid spread -plants maintain a higher level of virus?
- Higher levels of seed contamination?
- Symptoms: variety dependent; mild mosaic and distortion in leaves and discoloration, malformation and necrotic lesions on fruit

- Sequence of the viral genome (RNA)-relatively divergent and may be recombinant
- ToBRFV shares many properties with other tomato tobamoviruses and that similar management tools can be used

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Primary inoculum sources of ToBRFV

- Seeds
- Soil
- Weeds



Secondary inoculum sources and spread

- Hands
- Tools (knife, shears and etc.)
- Equipment (tractor, stakes, trellising ropes, etc.)
- Pollinators or animals? (Bumblebees in greenhouse)


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Field monitoring and early detection of ToBRFV

(New threat to tomato and pepper production in Florida)

- **The risk of a ToBRFV outbreak in an open field production is lower.**
- **However, it is important to monitor fields (and test) for ToBRFV.**
- **Growers are encouraged to scout their fields and collect suspected samples.**
- **Samples can be submitted to my lab (or the Plant Diagnostic Clinic) at SWFREC in Immokalee for diagnosis.**
- **We can help you with the diagnostics.**

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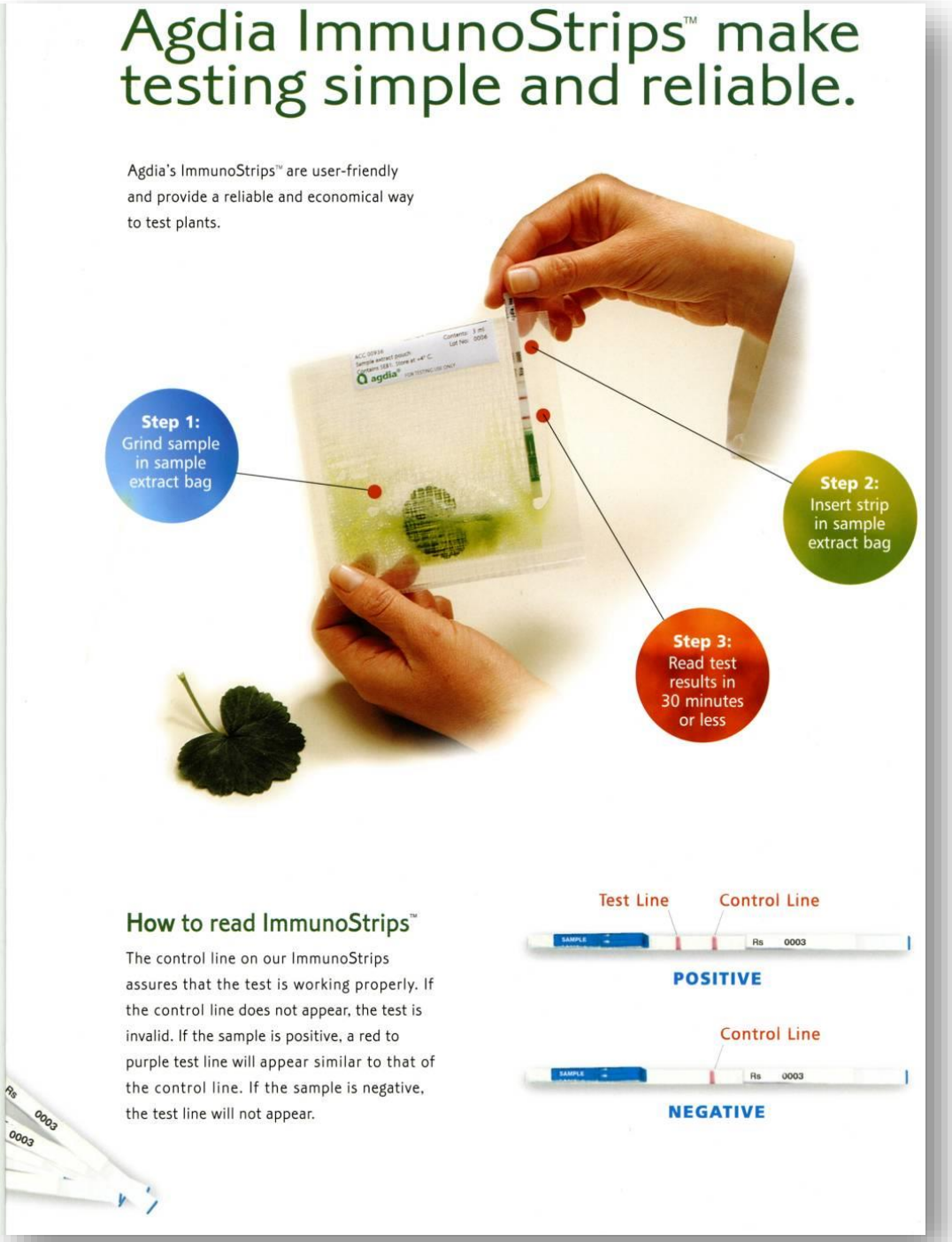

Immunostrips for Detection of Tobacco mosaic virus (TMV)

- Rapid and precise
- Easy to use
- Detection in the field
- No equipment needed
- Sensitive

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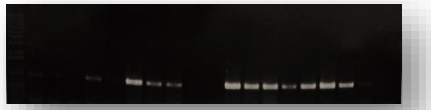
Lab identification of ToBRFV in resistant tomato cultivars with tobamovirus symptoms

Typical tobamovirus symptoms in Tm-2^2 varieties

Positive test with TMV immunostrips

Confirm tobamovirus by RT-PCR



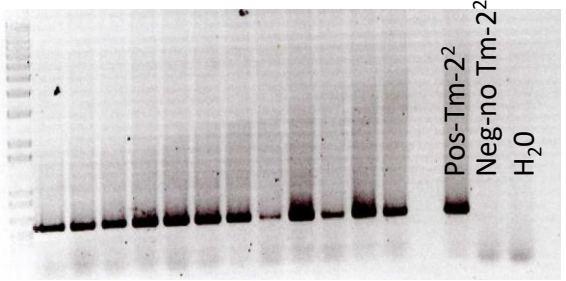
Confirm ToBRFV by sequencing RT-PCR fragments and comparing with database

If sequence is >90% identical to ToBRFV → **Isolate of ToBRFV**

If sequence is >90% identical to other tobamovirus → **Isolate of this tobamovirus**

If sequence is <90% identical to tobamovirus sequences → **Isolate may be a new tobamovirus**

Confirm tomato is a resistant variety by PCR for Tm-2^2 gene



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Integrated Pest Management of ToBRFV

Before growing season

- Use certified virus-tested seeds (request a certificate from your seed company)
- Plant virus-free transplants -look for disease symptoms
- Disinfect your production system

During the growing season

- Monitor for symptoms and <u>remove infected plants</u>
- Worker and other sanitation
- Minimize touching of plants
- Effective diagnostics
- Removal of infected plants

After the growing season

- Sanitation, sanitation, sanitation
- Rotation

Long term

- Identify sources of resistance
- Cross protection
- Grafting on resistant rootstocks (eggplant)

Greenhouse disinfectant- another product is Virkon

Cross protection of tomato with a mild ToMV strain

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Most effective disinfectants against tomato viruses

Disinfectants	PepMV	ToMV	TMV
Clorox (10%)	+	+	+
Virkon S (2%)	+	+	+
Nonfat dry milk (20%)	+	+	+
Lysol (50%)	+	+	+

Source: Li et al., 2015

Summary

- ToBRFV has emerged globally as a new threat to tomato production, particularly in greenhouses.
- It breaks Tm-2^2 resistance gene in tomato (and L gene in pepper).
- There is no a ToBRFV-resistant tomato variety.
- Tobamovirus-free certified seeds or transplants should be planted.
- ToBRFV cannot be diagnosed based on symptoms only.
- Quick and easy onsite diagnostic tests are available (immunostrips).
- More sensitive molecular tests needed for conformation of ToBRFV infection, and these tests are available through diagnostic clinics.
- Integrated Pest Management (IPM) is necessary.
- Sanitation and use of disinfectants are essential for management of ToBRFV.
- Rotation with a non-host crop should be considered.

Photos: Aviv Dombrovsky

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Take home message

- **Sanitation, disinfecting the greenhouse and/or field structures and trellising ropes**
- **Using tobamovirus-free seed lots or transplants**
- **Using tobamovirus-resistant varieties**
- **Early identification and removal of infected plants**
- **Disinfection of working tools and equipment**
- **Sanitation, sanitation and sanitation!**

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Acknowledgements

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- Various internet sources

Citrus Pathology Lab Members

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Thank You!

Any question?

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