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
Different viruses can cause very similar symptoms

Tobacco mosaic virus symptoms

Cucumber mosaic virus symptoms

ToBRFV
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
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
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
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
ToBRFV symptoms on tomato

Photos: Luria et al., 2017
What is different about ToBRFV?

• Breaks Tm-2² 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
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)
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.
Immunostrips for Detection of Tobacco mosaic virus (TMV)

- Rapid and precise
- Easy to use
- Detection in the field
- No equipment needed
- Sensitive
Lab identification of ToBRFV in resistant tomato cultivars with tobamovirus symptoms

1. Typical tobamovirus symptoms in Tm-2² varieties
2. Confirm tomato is a resistant variety by PCR for Tm-2² gene
3. Confirm tobamovirus by RT-PCR
4. Confirm ToBRFV by sequencing RT-PCR fragments and comparing with database
5. Isolate of ToBRFV
   - If sequence is >90% identical to ToBRFV
6. Isolate of this tobamovirus
   - If sequence is >90% identical to other tobamovirus
7. Isolate may be a new tobamovirus
   - If sequence is <90% identical to tobamovirus sequences
8. Positive test with TMV immunostrips
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 remove infected plants
- 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)
# Most effective disinfectants against tomato viruses

<table>
<thead>
<tr>
<th>Disinfectants</th>
<th>PepMV</th>
<th>ToMV</th>
<th>TMV</th>
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<tbody>
<tr>
<td>Clorox (10%)</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Virkon S (2%)</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Nonfat dry milk (20%)</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Lysol (50%)</td>
<td>+</td>
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Source: Li et al., 2015
Summary

- ToBRFV has emerged globally as a new threat to tomato production, particularly in greenhouses.
- It breaks Tm-2² 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.
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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Thank You!

Any question?

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